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**NAVAL  
POSTGRADUATE  
SCHOOL**

**MONTEREY, CALIFORNIA**

**THESIS**

**EVALUATION OF THE LITTORAL COMBAT SHIP (LCS)  
POTENTIAL FOR THE TURKISH NAVY**

by

Aykut Kertmen

September 2006

Thesis Advisor:  
Second Reader:

Edward Fisher  
Orin Marvel

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**REPORT DOCUMENTATION PAGE***Form Approved OMB No. 0704-0188*

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<b>1. AGENCY USE ONLY (Leave blank)</b>	<b>2. REPORT DATE</b> September 2006	<b>3. REPORT TYPE AND DATES COVERED</b> Master's Thesis	
<b>4. TITLE AND SUBTITLE</b> Evaluation of the Littoral Combat Ship (LCS) Potential for the Turkish Navy		<b>5. FUNDING NUMBERS</b>	
<b>6. AUTHOR(S)</b> Aykut Kertmen			
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> Naval Postgraduate School Monterey, CA 93943-5000		<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>	
<b>9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> N/A		<b>10. SPONSORING/MONITORING AGENCY REPORT NUMBER</b>	
<b>11. SUPPLEMENTARY NOTES</b> The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
<b>12a. DISTRIBUTION / AVAILABILITY STATEMENT</b> Approved for public release; distribution is unlimited		<b>12b. DISTRIBUTION CODE</b>	
<b>13. ABSTRACT (maximum 200 words)</b>  This thesis will examine the potential of the two competing designs for the Littoral Combat Ship (LCS), with regard to potential deployment of this vessel type by the Turkish Navy. The first design is by Lockheed Martin and has been designated the USS Freedom as the U.S. Navy's first LCS. The second design is by General Dynamics. This thesis will focus on the LCS usage concepts in Naval Capability Pillars and Information Operations.  As a transformation platform, the LCS will be critical in implementing new operational concepts and in providing a focused, littoral mission platform for joint forces. Its superior speed and maneuverability; low radar, infrared, and acoustic signatures; and ability to lay distributed sensor fields are all fundamental to mission success. It will also carry a "squadron" of unmanned vehicles (air, surface, and undersea) that will considerably extend its sensor and weapon coverage and provide substantial Anti-Submarine Warfare (ASW) capabilities.  This thesis will also discuss present and future platforms and their concepts of operation in Turkish littoral waters (Aegean Sea, Black Sea, and Mediterranean Sea).			
<b>14. SUBJECT TERMS</b> LCS, Littoral Combat Ship, Littoral Warfare, Force Transformation, Turkish Navy, Surface Combatant, United States Navy, Network-Centric Warfare, Electronic Warfare		<b>15. NUMBER OF PAGES</b> 107	
<b>16. PRICE CODE</b>			
<b>17. SECURITY CLASSIFICATION OF REPORT</b> Unclassified	<b>18. SECURITY CLASSIFICATION OF THIS PAGE</b> Unclassified	<b>19. SECURITY CLASSIFICATION OF ABSTRACT</b> Unclassified	<b>20. LIMITATION OF ABSTRACT</b> UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)  
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**EVALUATION OF THE LITTORAL COMBAT SHIP (LCS) POTENTIAL FOR  
THE TURKISH NAVY**

Aykut Kertmen  
Lieutenant Junior Grade, Turkish Navy  
B.S., Turkish Naval Academy, 2000

Submitted in partial fulfillment of the  
requirements for the degree of

**MASTER OF SCIENCE IN SYSTEMS ENGINEERING**

from the

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## ABSTRACT

Peace at home, peace in the world.

Mustafa Kemal Ataturk  
The founder and the first president of the Turkish Republic

This thesis examines the potential of the two competing designs for the Littoral Combat Ship (LCS), with regard to potential deployment of this vessel type by the Turkish Navy. The first design is by Lockheed Martin and has been designated the USS Freedom as the U.S. Navy's first LCS. The second design is by General Dynamics. This thesis focuses on the LCS usage concepts in Naval Capability Pillars and Information Operations.

As a transformation platform, the LCS will be critical in implementing new operational concepts and in providing a focused, littoral mission platform for joint forces. Its superior speed and maneuverability; low radar, infrared, and acoustic signatures; and ability to lay distributed sensor fields are all fundamental to mission success. It will also carry a “squadron” of unmanned vehicles (air, surface, and undersea) that will considerably extend its sensor and weapon coverage and provide substantial Anti-Submarine Warfare (ASW) capabilities.

This thesis also discusses present and future platforms and their concepts of operation in Turkish littoral waters (Aegean Sea, Black Sea, and Mediterranean Sea).

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## ACKNOWLEDGMENTS

I gratefully thank Professor Edward Fisher and Professor Orin Marvel who guided this work and helped whenever I was in need of assistance. They answered all my questions patiently. Without their help, this work would not be possible. I would also like to thank my editor, Erika Faust, for her great work in editing my thesis.

I would like to thank the Turkish Navy for giving me the opportunity to study at the Naval Postgraduate School.

I would also like to thank the following individuals who provided assistance and direction along the way:

1Lt. Aytug Denk, Turkish Air Force

1Lt. Ali Can Kucukozyigit, Turkish Army

Lt. J.G. Selcuk Hosoglu, Turkish Navy

Finally, I wish to thank my father, Naci Kertmen, my mother, Nevin Kertmen, and my sister, Burcu Kertmen, for their continuous support and encouragement.

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## EXECUTIVE SUMMARY

According to U.S. Navy guidelines, the U.S. Navy is required to project power from the sea and maintain consistent access in the littoral regions, which for naval vessels refers specifically to the transition areas between open ocean and more constricted shallower waters close to shore—the littorals. “Anti-access” threats from mines, submarines, and surface forces threaten the U.S. Navy’s ability to assure access to the littorals.

The Littoral Combat Ship (LCS) is being developed to address these concerns. The LCS design concept consists of two distinct parts, the ship itself and the mission package it carries and deploys. For the LCS, the ship is referred to as the “seaframe” and consists of the hull, command and control systems, launch and recovery systems, and certain core systems like radar and gun. A core crew will be responsible for the seaframe’s basic functions. Operating with these systems alone offers some capability to perform general or ordinary missions, such as support of special operations forces or maritime intercept operations.

The LCS’s focused missions are mine warfare, anti-submarine warfare, and surface warfare. The majority of the capabilities for these missions will come from mission packages. These packages are intended to be modular in that they will be interchangeable on the seaframe. Each mission package consists of systems made up of manned and unmanned vehicles and the subsystems these vehicles use in their missions. Additional crew will be needed to operate these systems. Each mission package is envisioned as being self-contained and interchangeable and will allow tailoring of LCS to meet specific threats.

The U.S. Navy characterizes the schedule for acquisition and deployment of the LCS as aggressive. To meet this schedule, the U.S. Navy is pursuing an evolutionary acquisition strategy. Rather than initially delivering a full capability, the program is structured to deliver incremental capabilities to the warfighter. To support this, LCS acquisition will be broken into “flights” for the seaframe and “spirals” for mission

packages in order to develop improvements while fielding technologies as they become available. The initial flight of ships, referred to as Flight 0, will serve two main purposes: provide a limited operational capability, and provide input to the Flight 1 design through experimentation with operations and mission packages. Flight 1 will provide more complete capabilities but is not intended to serve as the sole design for the more than 50 LCS the U.S. Navy ultimately plans to buy.

The U.S. Navy and Lockheed Martin signed a contract for detailed design and construction of the first Flight 0 ship in December 2004, and the ship builder is expected to deliver the ship to the U.S. Navy in fiscal year 2007. The U.S. Navy will then begin testing and experimenting with the ship, using the first mission package—mine warfare. A date for any deployment with the fleet has not been determined.

Detailed design and construction for the first General Dynamics design ship is scheduled to begin in fiscal year 2006 and delivery is scheduled for fiscal year 2008. The delivery of the first anti-submarine and surface warfare mission packages is aligned with the delivery of the second Flight 0 ship. The U.S. Navy will choose designs for further development in fiscal year 2007.

## I. INTRODUCTION

Small network combatants have an important role to play in 21<sup>st</sup> century naval warfare, and the reconfigurable Littoral Combat Ship may make important warfighting contributions as part of the Navy's 21<sup>st</sup> century "Total Force Battle Network" (TFBN).<sup>1</sup>

Robert O. Work  
Center for Strategic and Budgetary Assessments

### A. AREA OF RESEARCH

This thesis examines the potential of the two competing designs for the Littoral Combat Ship (LCS). The first design is by Lockheed Martin and has been designated the USS Freedom as the U.S. Navy's first LCS. The second design is by General Dynamics. This thesis focuses on the LCS usage concepts in Naval Capability Pillars and Information Operations.

As a transformation platform, the LCS will be critical in implementing new operational concepts and in providing a focused, littoral mission platform for joint forces. Its superior speed and maneuverability; low radar, infrared, and acoustic signatures; and ability to lay distributed sensor fields are all fundamental to mission success. It will also carry a "squadron" of unmanned vehicles (air, surface, and undersea) that will considerably extend its sensor and weapon coverage providing substantial Anti-Submarine Warfare (ASW) capabilities.

This thesis also discusses present and future platforms and their concepts of operation in Turkish littoral waters (Aegean Sea, Black Sea, and Mediterranean Sea).

Ships intended to fight in the relatively cluttered environment of the littorals should be small, nimble, lightly manned, and expendable. The intent is to swarm over an adversary.

---

<sup>1</sup> Work and Center for Strategic and Budgetary Assessments, Washington D.C., 2004.

This thesis will be used as an initial starting point for the LCS's test and evaluation process. The results from this thesis will be used to determine critical operational issues, measures of performance and effectiveness, and objectives to support operational Test and Evaluation (OT&E) of the LCS.

Further research will assist the Turkish Navy in evaluating future needs and requirements within the littoral combat environment.

## **B. RESEARCH QUESTIONS**

- What defines a Littoral Combat Ship (LCS)?
  - Development process
  - Main designs
- What are the LCS operational concepts in the Naval Capability Pillars (NCPs)?
  - Sea shield
  - Sea strike
  - Sea base
  - ForceNet
- How will the LCS implement these new operational concepts and provide a focused littoral mission platform for joint forces?
- What assets are other countries using for littoral combat?
- What are the electronic warfare (EW) capabilities of the LCS?
- How does the Turkish Navy conduct littoral combat?
  - Status of the Aegean Sea
  - Black Sea
  - Mediterranean Sea
- To what degree, if any, can the LCS effectively become an asset to the Turkish Navy for littoral combat?
  - Joint operations
  - Modular design
  - Cost-effective design

## C. DISCUSSION

LCS is envisioned to be a fast, agile, stealthy, relatively small, and affordable surface combatant. Its warfighting capabilities should be optimized for versatility in the littorals for anti-access and ‘gapfiller’ missions against asymmetric threats. A defining characteristic should be extensive reliance on a variety of organic unmanned vehicles. The ship should leverage transformational weapons, sensors, data fusion, C4ISR, materials, hull design, propulsion, ‘smart’ control systems, optimal manning concepts, and self-defense systems to enable it to survive and thrive in an adverse littoral environment.<sup>2</sup>

On November 1, 2001, the U.S. Navy announced that it would issue a revised request for proposal (RFP) for its future surface combatant program. Formerly known as DD-21 (for 21st Century Destroyer), the new program would be known as the DD(X), a large multi-mission destroyer from which the family took its name; the CG(X), a large multi-mission guided missile cruiser; and a LCS, small “focused mission” ship. For the next several decades, these three new “advanced technology surface combatants” would operate alongside a large “legacy” force of over 80 multi-mission combatants designed during the Cold War for open-ocean warfare against the Soviet Navy.

Missions		LCS	DD(X)	CG(X)
Deep Water Operations	<b>ASW</b>	Yes	Yes	Yes
	<b>ASuW</b>	No	Yes	Yes
	<b>AAW</b>	Yes	Yes	Yes
	<b>Ship Interceptions</b>	No	Yes	Yes
	<b>Logistic support</b>	No	Yes	Yes
	<b>Aviation</b>	Yes	Yes	Yes
Littoral Warfare Operations	<b>ASV</b>	Yes	No	No
	<b>ASuW</b>	Yes <sup>3</sup>	Yes	Yes
	<b>AAW</b>	Yes	Yes	Yes
	<b>MW</b>	Yes	No	No

<sup>2</sup> Commander Naval Surface Forces Pacific, 2002.

<sup>3</sup> The LCS will conduct ASuW operations against small surface craft.

<b>Missions</b>		<b>LCS</b>	<b>DD(X)</b>	<b>CG(X)</b>
	<b>Coastal Suppression</b>	Yes	No	No
	<b>Embarked Force</b>	Yes	No	No
	<b>Logistic support</b>	Yes	Yes	Yes
	<b>Aviation (inc. UAVs)</b>	Yes	Yes	Yes

Table 1. Capabilities of U.S. Future Surface Combatants.

The LCS will be a “Network-Centric,” Advanced Technology Ship. The LCS will rely heavily on manned and unmanned vehicles to execute assigned missions and operate as part of a netted, distributed force. In order to conduct successful combat operations in an adverse littoral environment, the LCS will employ technologically advanced weapons, sensors, data fusion, command, control, communications, computer, intelligence, surveillance, and reconnaissance (C4ISR), hullform, propulsion, optimal manning concepts, smart control systems, and self-defense systems.

According to Captain Donald Bancrook, U.S. Navy, the LCS Naval Sea Systems Command (NAVSEA) Program Manager, the development and employment the LCS is like playing with LEGO’s®. The core will be standing by to receive additional blocks (modules). The actual mission modules will be delivered in standard-sized cargo containers. These containers are lowered through a door in the flight deck into the mission module area. The reconfigurable mission systems interface control document for the Littoral Combat Ship (LCS) for Detail Design Phase states:

The LCS platform shall be designed to accommodate multiple reconfigurable modular mission packages to accomplish focused missions via an open and modular design that provides flexibility and ease of upgrade while ensuring rapid and successful installation and integration of the mission packages to the platform. To permit use of a wide range of both present and future mission systems and to permit platform and mission systems to be developed independently, standard interfaces in the form of a standard technical architecture must be used. Industry shall design and build the LCS platform employing an open modular

architecture for mission systems based on this standard technical architecture. Separately, mission modules will be developed for the LCS based on this technical architecture.<sup>4</sup>

With consideration to the above discussion, this thesis will focus on the evaluation of the LCS as a potential asset for the Turkish Navy. The Turkish Navy currently uses Burak (Type A 69), Barbaros, Yavuz, Gabya (Perry), Tepe (Knox) class frigates and Kilic, Kartal, Dogan, Ruzgar, Yildiz class Guided Missile-Fast Attack craft for littoral combat operations. This thesis will include comparisons between these platforms, the LCS, and other types of littoral combat assets.

Another aspect of the thesis will be an examination of the different design capabilities of the LCS with respect to littoral combat operations. Mine Warfare (MW), Anti-Submarine Warfare (ASW), and electronic Warfare (EW) will be examined with regard to their critical roles in littoral combat.

#### **D. ROADMAP OF THE THESIS: A CHAPTER OUTLINE**

Figure 1 shows the outline of the thesis.

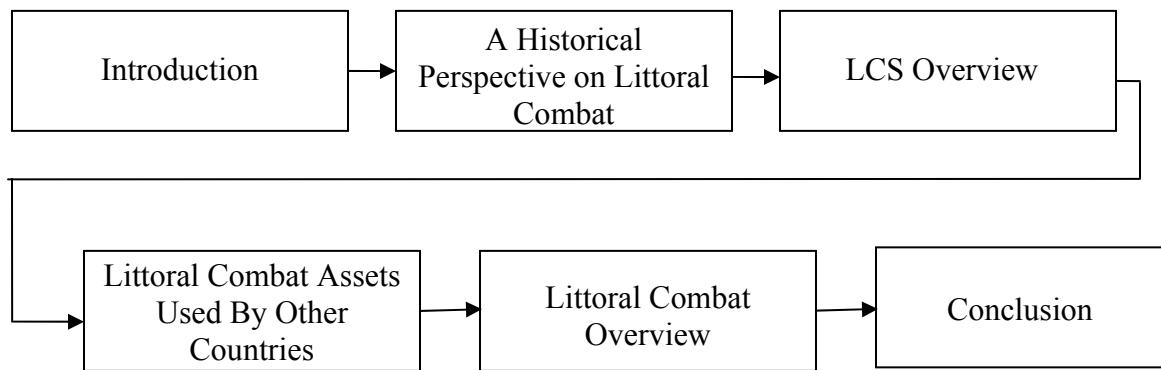


Figure 1. Roadmap of the Thesis

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<sup>4</sup> Bromley and Naval Postgraduate School, U.S., 2005.

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## II. LITTORAL COMBAT CONCEPTS

A good gun causes victory, armor only postpones defeat.

Vice Admiral S. O. Makarov

### A. LITTORAL COMBAT

Naval operations near land are best described as warfare in confined waters. Coastal waters off an enemy's homeland are not only where the enemy will test a navy's control, but also where he has the advantages of congestion and limited battle space. Warships which operate in this complex environment will have their warning and reaction times significantly reduced and their ability to maneuver will be compromised by virtue of the shallow water and the always present mine threat. Additionally, classification and deconfliction are crucial given the abundance of aircraft and shipping in this environment.<sup>5</sup> More than 70% of the earth's population resides within a few hundred miles of the world's coastlines, near waterways teeming with merchant ships.

The littoral—or coastal—waters of the world can be choked with mines, blocked by submarines, or subject to raids by small, armed boats. These are threats that cannot be ignored, avoided, or bypassed. The littoral as defined by U.S. DoD does not refer only to waters close in to shore, but can mean an area several hundred miles out to sea. Some of the dangers in the littoral are unsophisticated in nature, such as contact mines or suicide boats. Others are more complex, such as air independent propulsion (AIP) submarines armed with supersonic anti-ship cruise missiles or long-range, high-speed torpedoes. These threats can limit access, impede an invasion force, interdict a logistics effort, and damage capital ships.

#### 1. Littoral Environment

What constitutes the littoral region currently has no standardized definition; the ranges included in the different definitions differ widely. In general, however, it is agreed that in the littoral environment the advantage goes to the defending forces. It will be

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<sup>5</sup> Wade Hughes and Kemple, 1996.

complex and congested, with potential threats dispersed amongst a large number of civilian aircraft, ships, and real estate. It will include areas of deep and shallow water and the latter with its poor acoustic environment will favor the use of submarines and mines by an enemy. The proximity of hostile airfields and ports can also allow a large number of sorties to be made against an approaching expeditionary force.

One of the most noticeable differences in the various definitions in littoral warfare is the difference in the definition of ranges in the littoral battlespace. Those used by the U.S. can be twice those used by its NATO Allies. This difference has two main causes: one, the use of carrier based airpower by the U.S., and two, that most European concepts of force employment in the littoral are based on Baltic or Mediterranean scenarios.<sup>6</sup>

U.S. Naval Doctrine Publication I, “Naval Warfare,” defines “littoral” as “those regions relating to or existing on a shore or coastal region, within direct control of and vulnerable to the power of naval expeditionary forces.”<sup>7</sup> The U.S. Navy further describes littoral warfare as.”..the ability to mass overwhelming joint and allied force and deliver it ashore to influence, deter, contain and overcome the enemy.”<sup>8</sup>

In the United Kingdom (U.K.), the littoral region is defined in publication JWP 0-01.1<sup>9</sup> as “coastal sea areas and that portion of the land that is susceptible to influence or support from the sea.” “Coastal sea areas” traditionally imply ranges such that naval forces can be deployed over the horizon, where they cannot be detected visually or by conventional land-based radar, but not necessarily any further than that. This definition also does not fully take into account the development of long-range standoff weapon systems such as Tomahawk and Storm Shadow.

Although it is possible to influence events on land by projecting power over littoral waters and thus avoid the need to operate in them, eventually logistic support from the sea will be required to sustain land forces. Also, if required, amphibious forces

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<sup>6</sup> Royal Institution of Naval Architects, 2004.

<sup>7</sup> U.S. Department of the Navy, 1994.

<sup>8</sup> Anonymous, 1994.

<sup>9</sup> MoD, 2001.

must transit through littoral waters to conduct a landing. Even in operations with limited objectives or operations other than war, such as low intensity conflicts, noncombatant evacuation operations (NEO), peacekeeping, and showing the flag operations, the naval role is to exert influence near land with a constant and visible presence. At some point, naval forces must operate within the littoral.<sup>10</sup>

The extreme littorals can be described as follows:

- Complex environment – Shallow waters, archipelago, temperature and salinity layers makes hiding easy and detection difficult.
- Heavy sea traffic – ferries, merchant ships, fishing and pleasure boats.
- A broad spectrum of threats – Anti-ship Missiles, Mines, Torpedoes, Artillery, Swimmers, Small units.
- Short distances – Lack of space for defense in depth and for maneuvering.
- Short reaction times.<sup>11</sup>

With an average water depth of 60-65 m, the Turkish Navy's areas of responsibility, the Aegean Sea, the Sea of Marmara (Figure 2), the Mediterranean Sea (Figure 4), and the Black Sea (Figure 3) are certainly examples of a littoral environment.

---

<sup>10</sup> Wade Hughes and Kemple, 1996.

<sup>11</sup> Royal Institution of Naval Architects, 2004.



Figure 2. The Aegean Sea and The Sea of Marmara<sup>12</sup>



Figure 3. The Black Sea<sup>13</sup>

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<sup>12</sup> NASA, 2006.

<sup>13</sup> NASA, 2006.



Figure 4. The East Mediterranean Sea<sup>14</sup>

## 2. Littoral Operations

To win on this 21st Century battlefield, the U.S. Navy must be able to dominate the littorals, being out and about, ready to strike on a moments notice, anywhere, anytime, without a permission slip.

Admiral Vernon E. Clark  
Chief of Naval Operations

The focus of naval operations has moved away from the cold war blue-water fleet actions towards low- and medium-intensity operations in the littoral regions within a joint integrated battlespace, as has been demonstrated in recent conflicts. The concept of employing naval forces in the littoral, though, is not new and is defined by both offensive and defensive requirements. The offensive requirement is primarily driven by the demands of expeditionary warfare and the need to position forces (either joint or coalition) into a position of advantage from which force can be rapidly applied ashore. The defensive requirement, however, is quite different and primarily revolves around the

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<sup>14</sup> NASA, 2006.

many facets of homeland security. Therefore, the requirements of each individual navy concerning littoral warfare will be determined by their individual balance between homeland security and expeditionary warfare.<sup>15</sup>

Over three-quarters of the world's population and over 80 percent of all capital cities are found within 200 nm of the coast, and nearly all the international trade takes place in this littoral region. The littoral waters are not only critical for any potential adversary; they are also target-rich environments for terrorists. The littoral is a complex operating environment. These waters are usually congested and shallow with difficult acoustic and atmospheric conditions. Significant numbers of friendly and neutral ships and aircraft are to be found in the littoral waters. The above characteristics invite threats such as mines, diesel submarines, fast attack craft/fast inshore attack craft, anti-ship cruise missiles, and aircraft to deny access for naval forces, friends, and partners.<sup>16</sup>

Traditionally, deepwater naval fleets were developed so that they could carry out the deep water role along with homeland defense. Many of the items of equipment aboard the vessels were purposefully tailored to improve their performance in the area of homeland defense. However, with the change to littoral operations, different priorities have been established and these multi-role vessels are no longer ideally suited to their emerging operational roles. The ship operations that are required in the relevant battlespaces are summarized in Table 2.

<b>Ship Missions</b>		<b>Deep Water Operations</b>	<b>Littoral Warfare Operations</b>	
			<b>Homeland</b>	<b>Expeditionary</b>
<b>Anti-submarine Warfare</b>		Required	Required	Required
<b>Mine Counter Measures</b>	<b>Organic</b>	Possible	Required	Required
	<b>Wide Area</b>	Not Required	Not Required	Required
<b>Anti-Surface Warfare</b>	<b>DD/FF</b>	Required	Possible	Required
	<b>FICA/PSB</b>	Not Required	Required	Required

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<sup>15</sup> Royal Institution of Naval Architects, 2004.

<sup>16</sup> Jundquist, 2005.

Ship Missions		Deep Water Operations	Littoral Warfare Operations	
			Homeland	Expeditionary
Anti-Air Warfare	Point (self)	Required	Possible	Required
	Local	Required	Not Required	Required
<b>Ship Interceptions</b>		Possible	Required	Not Required
<b>Coastal Suppression</b>		Not Required	Not Required	Required
<b>Embarked Force</b>		Not Required	Required	Required
<b>Logistic Support</b>		Required	Not Required	Possible
<b>Aviation (inc. UAVs)</b>		Required	Possible	Required

Table 2. Ship Operations by Battlespace Region<sup>17</sup>

While operating in open waters, warships count on the inherent difficulties in scouting such vast areas to conceal their positions. Most countries lack the reconnaissance and surveillance capabilities to detect and localize naval forces far out at sea. This changes, however, if naval forces move closer to an enemy's coast to conduct littoral sea control, protect friendly or neutral merchant shipping, or bring targets ashore within range of power projection. Having to fight in the enemy's neighborhood can offset advantages in training and equipment as it drastically simplifies enemy scouting, logistics, force concealment, and weapon range problems.

Table 13 details some of the possible threats that platforms may encounter in either the deep water or the littoral battlespace. The accepted standard for littoral threats is that the enemy knows his local waters better than anyone else. If tactically smart, he can use the region's geography and modern communications to ambush naval forces in transit or when otherwise vulnerable. Imagine that an adversary distributes "spotters" on board merchant ships or fishing boats throughout his maritime neighborhood. These scouts detect a strike group at tactically significant distances and report in via satellite phones or other secure means. Despite the enemy's inability to conduct a long-range strike or maintain a near-real-time, over-the-horizon picture, they position assets to lay an ambush along the strike group's most likely track. Despite the employment of emissions

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<sup>17</sup> Royal Institution of Naval Architects, 2004.

control and operational deception by a strike group that is entering an area, the scouts report its location since it cannot hide in such confined waters. The enemy saturates the formation with anti-ship cruise missiles (ASCMs) fired by fast patrol boats hiding amid dense, regional shipping and from concealed positions that take advantage of coastal topography. Even with the formation's advanced air-defense systems, the laws of probability suggest that some missiles will get through. If final active and passive, electronic defenses or hard-kill, close-in defenses fail to neutralize the threat, warships will take hits. Fast guided-missile patrol boats and basic ASCMs are relatively inexpensive and easy to field; a missile does not need to be complex if enough are fired such that a formation's surface-to-air missile (SAM) inventories are depleted or their capabilities overwhelmed. The more threat axes the enemy fires from, the more difficult the defensive problem for a formation.<sup>18</sup>

Threat	Deep-water Warfare	Littoral Warfare
Aircraft Attack—ASM	Yes	Yes
Aircraft Attack—Bombs	Yes	Yes
Ship-Based Helicopter—ASM	Yes	Yes
Land-Based Helicopter—ASM	No	Yes
Long-Ranged, Land-Based UAV	Yes	Yes
Short-Ranged, Ship-Based UAV	Yes	Yes
Short-Ranged, Land-Based UAV	No	Yes
Ship Launched ASM	Yes	Yes
Surface Ship Gunfire	Yes	Yes
Submarine Launched ASM	Yes	Yes
Submarine Launched Torpedo	Yes	Yes
Nuclear Threat	Yes	Yes
Chemical Threat	No	Yes
Biological Threat	No	Yes
Mines	No	Yes

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<sup>18</sup> Hughes and Hughes, 2000.

Threat	Deep-water Warfare	Littoral Warfare
FAC	No	Yes
FIAC	No	Yes
Manned Surface Explosive Craft	No	Yes
USV	No	Yes
Mini Submarines	No	Yes
Manned Torpedoes	No	Yes
UUV	No	Yes
Land Based Gunfire	No	Yes
Land Based ASM	No	Yes

Table 3. Threats to a Naval Platform<sup>19</sup>

The proliferation of sophisticated ASCMs threatens warships' ability to operate and survive in the littoral. The threat to surface ships from sophisticated anti-ship missiles is increasing. Nearly 70 nations have deployed sea- and land-launched cruise missiles, and 20 nations have deployed air-launched cruise missiles. There are over 100 existing and projected missile varieties with ranges up to about 185 miles. The next generation of anti-ship cruise missiles—some of which are now expected to be fielded by 2007—will be equipped with advanced target seekers and stealth design. These features will make them even more difficult to detect and defeat.<sup>20</sup>

The same is true with regard to torpedo defense, especially with the limitations on evasive maneuvering in confined waters, challenges in detection, and the lack of anti-torpedo, hard-kill capability. For the enemy's bottomed or hovering submarines fire wake-homing torpedoes into the formation, all they have to do is sit and wait for the formation to steam over them. Prior to the ambush, the submarines could also deploy minefields that are optimized with their knowledge of the bottom topography, so that the

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<sup>19</sup> Royal Institution of Naval Architects, 2004.

<sup>20</sup> United States General Accounting Office, 2001.

torpedo and missile attacks herd the force into another trap. Combat generally favors the side that most innovatively employs existing platforms and weapons, fires first, and fires effectively and in mass using the least complex plans.<sup>21</sup>

The primary goal of anti-submarine warfare is to deny the enemy effective use of its submarines against navy ships. Naval forces use antisubmarine sensors and weapons on their surface ships, submarines, and aircraft, along with fixed and deployable acoustic and non-acoustic sensors to detect, track, and destroy enemy submarines. Figure 5 illustrates antisubmarine warfare functions.

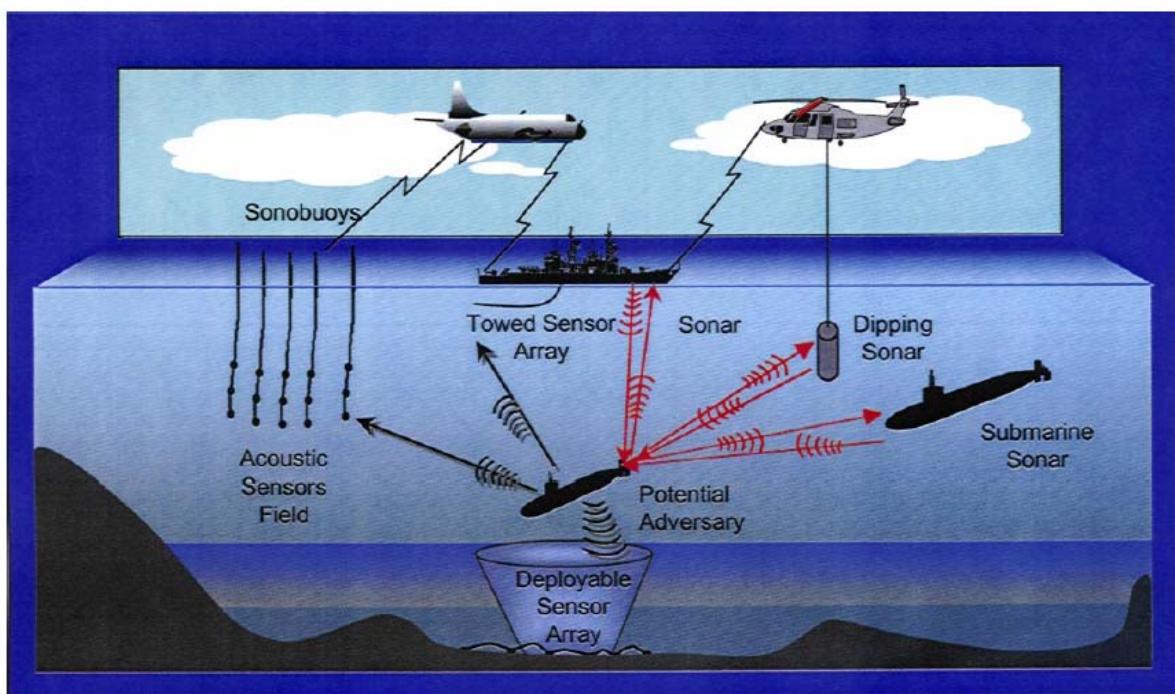


Figure 5. Techniques Used in Littoral Regions to Detect and Locate a Diesel Submarine<sup>22</sup>

Another significant littoral threat as noted above is sea mines. Enemy sea mines have been responsible for 14 of the 19 U.S. Navy ships destroyed or damaged since 1950. Some countries are continuing to develop and proliferate mines that are increasingly more difficult to detect and neutralize. To appreciate the complexity of the mine

<sup>21</sup> Hughes and Hughes, 2000.

<sup>22</sup> United States General Accounting Office, 2001.

countermeasures warfare task, it is important to understand the environment in which mine warfare operations take place. Figure 6 illustrates the five water depths of the undersea battlespace and the types of mines found at each depth.

Recent operations in Iraq and Afghanistan point to the need for persistent presence, assured access, long-range strike and a robust, naval surface fire support. Coalition mine warfare forces located and destroyed numerous mines and mine-like objects before humanitarian supplies could proceed into Iraqi ports. The fact that almost a dozen actual mines were located and destroyed is indicative of the reality of the mine threat in littoral waters and their tremendous impact on operations. Once cleared of the mine threat, the U.K. Royal Navy surface combatants were able to position themselves to deliver naval fire to surface targets on the Al Faw Peninsula in Southern Iraq. The U.S. Navy units did not have the shallow draft to participate in delivering these fires, but would have been able to participate if longer-range precision fires were available. But, the U.S. Coast Guard's assets—key elements of the Navy-Coast Guard “National Fleet” concept—did indeed work in areas that otherwise constrained larger warships.<sup>23</sup>

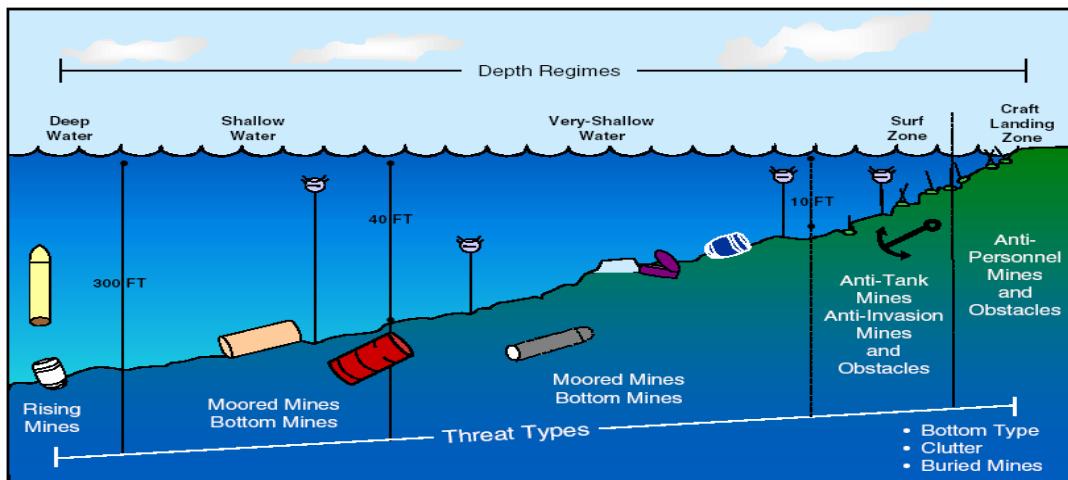


Figure 6. Sea Mine Threats by Water Depth<sup>24</sup>

<sup>23</sup> Lundquist, 2004.

<sup>24</sup> United States General Accounting Office, 2001.

During the Gulf War, two Navy ships—the USS Princeton and the USS Tripoli—were severely damaged and seven sailors injured by sea mines. Figure 7 shows the damage 10 feet below the waterline on the USS Tripoli. The USS Tripoli was damaged by an Iraqi sea mine in the Persian Gulf on February 18, 1991.



Figure 7. Sea Mine Damage to the USS Tripoli in the Gulf War<sup>25</sup>

The U.S. Marine Corps' future war-fighting concept for littoral operations will stress speed, maneuverability, and avoidance of enemy strong points to achieve military objectives. This concept assumes that amphibious assaults will be launched from at least 25 nautical miles from shore to enhance surprise and the survivability of the fleet and invading forces. According to the Marine Corps, operating at this distance from shore and the need to neutralize enemy artillery at its maximum range results in a near-term requirement for naval gunfire support from 41 to 63 nautical miles to support amphibious assault landings and combat operations ashore. However, the Marine Corps expects to conduct operations farther inland in the future and has revised the required range for future ship-based fire support to 200 nautical miles. Figure 8 illustrates the naval surface fire support operations.

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<sup>25</sup> United States General Accounting Office, 2001.

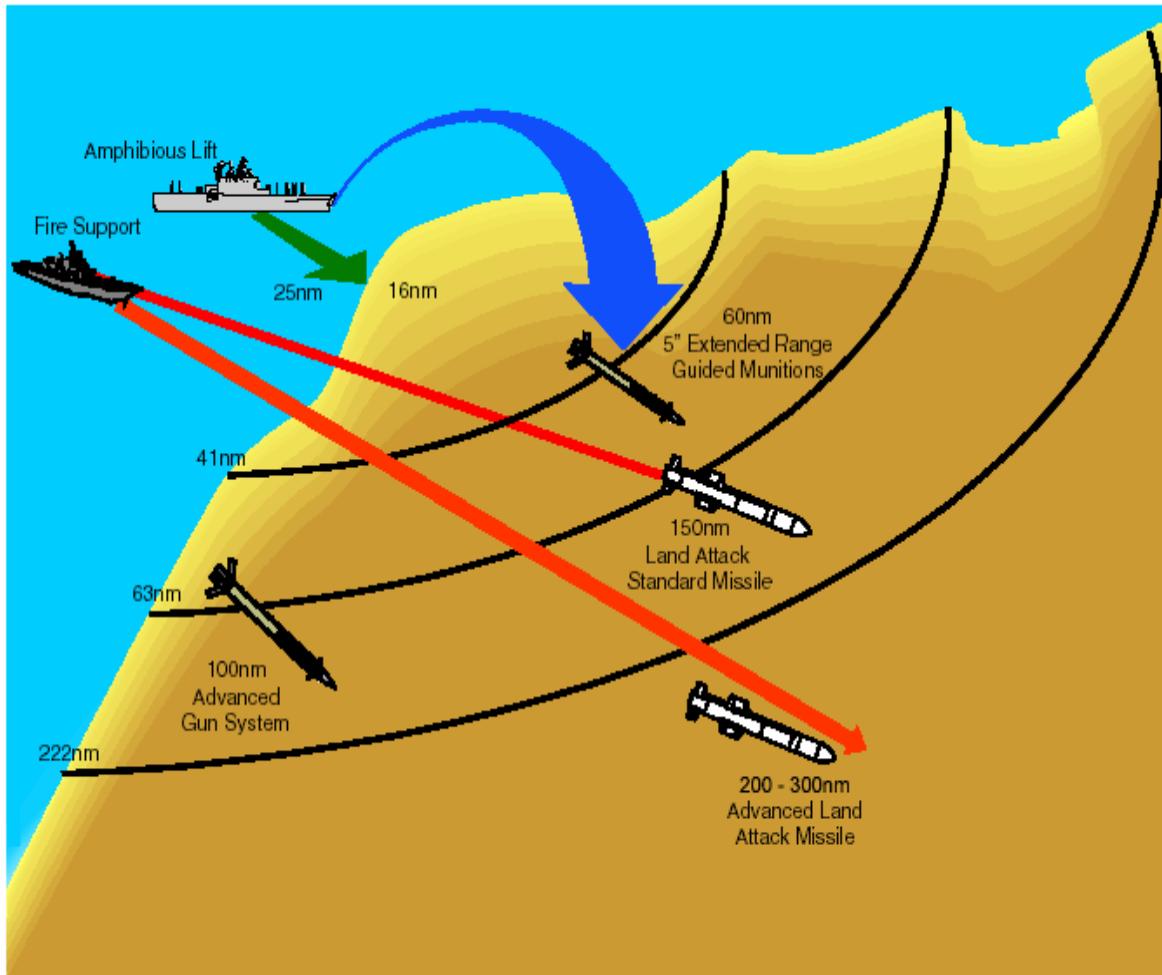


Figure 8. Naval Surface Fire Support Operations<sup>26</sup>

The nature of expeditionary operations involves moving troops and material ashore. While expeditionary forces may have the ability to fly over a contested beachhead and operate far inland, access along the littoral is still a strategic, operational, and tactical imperative. Sea-based expeditionary forces can be deployed to virtually anywhere in the world on short notice because the preponderance of their equipment, vehicles, ammunition and fuel are pre-positioned forward aboard ships, awaiting the call to head into theater and deliver the cargo to the troops. Large, forward-deployed logistics ships at locations such as Diego Garcia or in the Mediterranean Sea may be loaded with vehicles for the Marines, fuel for the Army, or bombs for the Air Force. Several ships together

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<sup>26</sup> United States General Accounting Office, 2001.

may constitute the equipment for a brigade or a division. The successful deployment of these ships into the port closest to where the expeditionary forces are being inserted is an operational imperative.

A good example of this concept in action is the recent deployment of the U.S. Army 101st Airborne during Operation IRAQI FREEDOM. Large, medium-speed roll-on/roll-off ships (LMSRs) from preloaded military sealift command and other fast sealift ships transported more than three million square feet of equipment that met the troops in the theater.

To operate effectively in the littoral, naval forces must be able to handle the inherent difficulties of this environment. Captain Wayne P. Hughes Jr., USN (Retired), author of *Fleet Tactics and Coastal Combat*, has characterized warfare in the littoral as “...warfare in confined and congested waters. In this arena, the enemy will not only contest our control, but will also use to his advantage the limited battlespace and congestion found in this environment.”<sup>27</sup>

Compared to the vastness of open ocean operations, the littoral areas are confined by geographical constraints that significantly reduce the size of the battlespace and increase the vulnerability of units operating within them. The very nature of the waters in this type of environment—often narrow, shallow, and bound by the shoreline creates unique challenges that lead to interesting insights. CDR John Stavridis, USN, former commanding officer of USS Barry (DDG 52), recently noted in a forum on naval tactics for small wars that operations in the littoral significantly reduce a ship’s ability to maneuver—an extremely uncomfortable operating environment for a commanding officer. In his account, CDR Stavridis discusses the operations that he and the USS Barry have been involved in the last two years. They have been in Haiti, the Adriatic and the Arabian Gulf. The ship routinely operated in waters as shallow as 50 feet with a navigational draft of 36 feet. The risk of grounding was therefore a serious concern.

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<sup>27</sup> Hughes and Hughes, 2000.

Highly competent and vigilant watch teams, both on the bridge and combat information center (CIC), were necessitated at all times, which was a significant energy drain upon personnel.

Detection and rapid engagement of suspected threats, however, are by no means easy tasks. First, sensors and guidance systems are affected by heavy land clutter, which results in severely degraded detection and tracking capabilities. Often false targets are created and, potentially worse, actual targets are masked. Second, and perhaps more important, the intrinsic density, clutter, and congestion within the littoral environment—tankers, freighters, fishing boats, and aircraft—result in uncertainties in identification and deconfliction. Time is therefore required to develop an accurate tactical picture before one can engage the enemy or the incoming threat. Unfortunately, time is a scarce commodity when it comes to self-defense in this arena.<sup>28</sup>

Rear Admiral Yedidia Ya'ari, Israeli Navy, discusses an anti-surface missile scenario in his essay, “The Littoral Arena: A Word of Caution.” The scenario serves well to put in perspective the time constraints and ambiguities of a surface missile attack in coastal waters. He describes the use of the Russian SS-N-22, a Mach 2-plus sea-skimmer missile, against a surface target 15 miles offshore. It is assumed that the ship is constantly tracked by coastal radar, and that the ship is unaware of when it has been targeted. The missile is launched and will impact the ship within 40 seconds. In order to react effectively, the ship “... must be ready not only to detect it [the missile] the instant it is launched but to have every countermeasure operating within the first thirty seconds. Setting aside the first five or ten seconds for resolving ambiguity in identification, the reaction time is reduced to some twenty seconds.”

Rules of engagement (ROE) thus tend to dominate the minds of the commanding officer and tactical action officers because of the need to respond quickly to threats. Incidents involving the USS Stark and the USS Vincennes have emphasized this issue. Failure to resolve uncertainty and a hesitation to react on the part of a ship may lead to a missile hit. On the other hand, quick and rapid reaction to what appears to be a threat may

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<sup>28</sup> Wade Hughes and Kemple, 1996.

lead to undesirable consequences. In order to avoid such incidents and possibly limit the escalation of conflicts, there has been an increased emphasis on restrictive control over commanding officers with regard to ROE. Often, the commanding officer is given rigid constraints on how and when to use weapons, which serves to seriously limit the ability of the ship to defend itself until it may be ultimately too late.

Another challenge in conducting operations in the littoral concerns human factors. People play a crucial role in operating the systems required to counter the inherent threat. It is by no means realistic to assume that shipboard personnel can continuously perform in a state of alertness for extended periods of time, especially with the knowledge that a mistake or malfunction of equipment could well result in the disablement or loss of the platform. Additionally, it is not possible to take down systems to conduct preventive maintenance on vital equipment, because this could degrade weapon and sensor performance. Obviously, the stress on shipboard personnel and the eventual degradation of equipment make naval forces more vulnerable to attacks in the long run.<sup>29</sup>

### **3. Littoral Navy**

A coastal country can be defined as a country that is located along the sea, but is without the ability to establish sea control outside its local waters. This country can, however, control its local waters quite effectively.<sup>30</sup>

Some general characteristics are shared by most such navies. First, coastal navies are prepared and trained exclusively for operations within the littoral environment. They understand and are fully acquainted with the geography and conditions of their local waters, which serve well to offer cover and protection to their forces. Second, since these coastal navies intend to operate in and control these waters, their weapon and sensor systems are optimized to operate without degradation in a near-land environment. Third, the ships and patrol craft of a coastal navy are relatively small and expendable. The proliferation of advanced missile technology allows the concentration of significant amounts of firepower on small platforms. These ships are designed for local operations and not long-distance operations. Lastly, these navies optimize their doctrine, tactics and

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<sup>29</sup> Wade Hughes and Kemple, 1996.

<sup>30</sup> Borrensen, 1994.

coordination to gain comparative advantages over forces not acquainted with their waters or the surrounding environment. This is particularly true when the coastal country can pick the time and place for engagement.<sup>31</sup>

The primary functions of the navies of these coastal countries can be broken down into three elements: protection against the illegal exploitation of natural resources within exclusive economic zones; a show of sovereignty and control over territorial waters; and, deterrence against invasion from the sea. In order to support these functions, the coastal country will most likely utilize a balanced approach with regard to its naval forces. Using this concept, a mixture of elements of the coastal defense system—surface, subsurface, air, and mine threats—are used to provide both a synchronized defense and a formidable offensive capability.

Synchronized defense is the ability to operate fast patrol boats and submarines within weapons range of each other, as well as inside the range of coastal artillery, land-based anti-ship missiles, mines, and attack aircraft. This complex operating environment forces the opponent to operate in one of two ways. One option is to perform all tasks simultaneously—ASUW, AAW, ASW, mine-clearance, etc. The other is to employ enough platforms that he can lose some and still fulfill all mission requirements one at a time.

Most countries realize, however, that in an open conflict or all-out war against a strong opponent with the will to carry on, they cannot guarantee victory. They could perhaps win some battles and cause damage to the opposing force, but they would not be able to sustain themselves in the long run. Coastal countries will therefore most likely conduct operations which aim to "... bleed the enemy's military and political resources, until he comes to the conclusion that the price of continuing the war exceeds any gain he might hope to reap from it." In other words it might be in the coastal country's interests to prolong the conflict to mount political pressure against such a conflict on the enemy's home front.<sup>32</sup>

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<sup>31</sup> Wade Hughes and Kemple, 1996.

<sup>32</sup> Borrensen, 1994.

As can be seen from the characteristics mentioned, the Turkish Navy has all of the characteristics of a coastal navy.

#### **B. PLATFORMS USED BY THE TURKISH NAVY FOR LITTORAL COMBAT**

In light of Turkey's membership in NATO, the role of the navy during the Cold War was to ensure the security of the Black Sea against Warsaw Pact states and to operate in the Mediterranean Sea to counter perceived threats in that region. Since the demise of the Soviet Union, the Turkish Navy has changed its thinking and adopted an expansion policy, venturing on "show the flag" missions.

The role of the Turkish Navy Forces Command (TNFC), as outlined by the 1998 White Paper of the Turkish Ministry of National Defense (MND), is to defend the country against threats from the sea and to provide security for shipping lanes. The change in the TNFC's new strategy that includes the high seas is defined in the White Paper as: The regional geography of Turkey and the security requirements of the shipping lanes make it necessary in the development of the Turkish Naval Force to combine defensive littoral warfare and open seas operations aimed at the control of the open seas. With the planned military investments, the Turkish naval force will be transformed from a force structure that is intended for littoral warfare to a force structure that is intended to have a strong say in the open seas and the littorals.

The role of the navy is therefore to maintain control of territorial waters and to defend national territory against threats from the sea. This is not only for the sake of national sovereignty but also for the sake of NATO membership. The navy's mission is also to help protect the country's sea lines of communications (SLOCs) and to assist operations designed to keep the ports open. In addition, it is part of the navy's mission to combat drug smuggling and international terrorism and to prevent large-scale, unauthorized, refugee movements.

During the Cold War, Turkey fulfilled a vital role for NATO in guarding the Turkish Straits, the passage through which the Soviet Black Sea Fleet would reach the Mediterranean. NATO was concerned that in the event of a conflict, Warsaw Pact forces could try to make a swift push through Thrace, the European part of Turkey, to seize the

Straits. Although this threat has greatly receded with the end of the Cold War, the Turkish Straits remain strategically important to Turkey, for a variety of reasons, and they figure prominently in Turkish naval planning.

The 11 September 2001 attacks on the United States prompted the TNFC to take additional measures to protect Turkish interests at sea against asymmetric threats. The TNFC increased security measures at all military bases and commercial ports, while armed coastal vessels have been conducting round-the-clock surveillance in the Black Sea, the Aegean Sea, and the Mediterranean Sea in addition to the Bosphorus Straits under Turkish control. Turkey's Coast Guard Command has also boosted its strength and added coastal vessels to ensure maritime safety and homeland security.

Safe access to the Aegean and the Mediterranean Sea ports is essential because around 90 percent of Turkey's trade is realized via sea routes.

The Turkish Navy currently uses:

- Burak (Type A 69)
- Barbaros
- Yavuz
- Gabya (Perry)
- Tepe (Knox) class frigates and;
- Kilic, Kilic II, Yildiz
- Dogan, Ruzgar
- Kartal class Guided Missile-Fast Attack crafts for littoral combat operations.

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### III. A HISTORICAL PERSPECTIVE ON LITTORAL COMBAT

Several forces shaped what is generally considered the best motor torpedo boat (MTB) of World War II, the Schnellboot.<sup>33</sup> These included the advancements in internal combustion engine technology, the invention of the modern torpedo, the restrictions of the 1919 Treaty of Versailles,<sup>34</sup> British naval hegemony, and an American contract for a luxury yacht. Sometimes referred to as the “S-Boat” or by the United Kingdom (U.K.) Royal Navy term (now archaic) “E-Boat” (Enemy Boat), the Schnellboot was a formidable assembly of technology, naval architecture, and highly trained men.

The large, highly capable Schnellboot design was only possible through the development of a suitable power plant. Its engine was extremely powerful, compact, robust, and relatively lightweight. The Schnellboot engines, like the boats themselves, underwent a constant evolutionary process, stressing individual quality and survivability over the production of large quantities of expendable materials. The boats were adapted to operate in increasingly harsh combat environments and required increases in engine performance to counter the growing weight of armor protection, anti-aircraft weaponry, and additional crewmen.<sup>35</sup>

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<sup>33</sup> The German term Schnellboot literally “speedboat” and its German abbreviation S-boot are used throughout along with the plural “Schnellboote” and “S-boote” in preference to the hybrid German/English terms “S-boat” and “S-boats.” Similarly German submarines are referred to as “U-boote” Unterseeboote; “undersea boats.”

<sup>34</sup> The Treaty of Versailles formally ended World War One between Germany and the Allied Powers primarily Great Britain France the United States and Italy was signed on 28 June 1919.

<sup>35</sup> Connelly and Krakow, 2003.

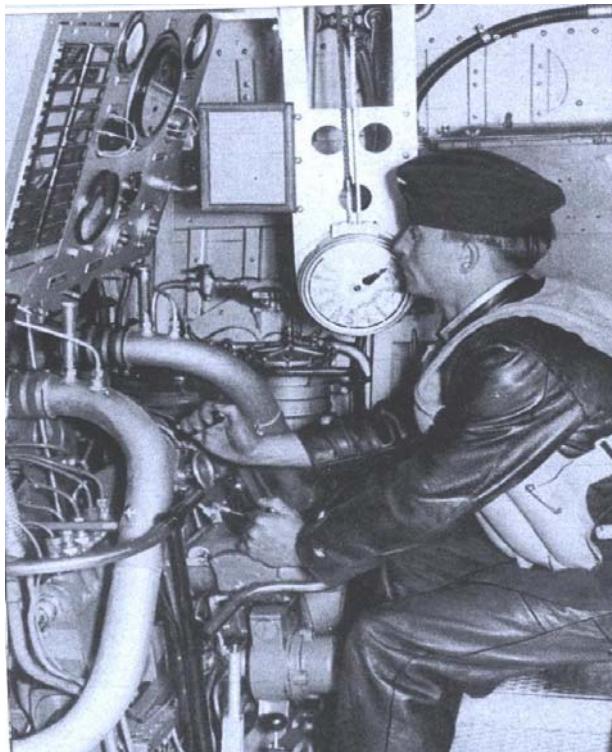


Figure 9. The Schnellboot Engine Room<sup>36</sup>

Large and robust, the wartime boats were built to withstand considerable wave buffeting, engine vibration, gun recoil, and battle damage. Boat construction took place primarily at the Lurssen boatyard in Vegesack, near Bremen. Numerous boats were also built by the Schlicht yard in Travemunde, and several were built at the Gusto Werke in Schiedam, the Netherlands, and at Danziger Waggonfabrik in Danzig (now Gdansk, Poland). The size and complexity of these boats were a drawback to Germany's industrial base, because they demanded large numbers of skilled laborers and considerable material resources.

The Schnellboot's main battery consisted of two 53.3 cm (21 inch) torpedo tubes mounted on the bow. S-boote typically went to action with one torpedo in each tube. Cradles for up to four extra torpedoes were mounted on the boat deck; however, two was the normal reserve load. Reserve torpedoes were less frequently carried in areas such as the English Channel, where the Allies employed effective countermeasures. The weight

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<sup>36</sup> Connelly and Krakow, 2003. A Schnellboot motorman sits by one of the engines. His right hand is moving the throttle based on orders from the bridge which were received on the telegraph to his right.

of the torpedoes adversely affected performance, especially of boats with armored Kaltte (Skull cap armored bridge dome), and the hit-and-run tactics rarely allowed the five minutes it took a well-trained crew to reload a tube.



Figure 10. The Schnellboot Main Armament<sup>37</sup>

Schnellboote usually operated at night in formations, which made communication especially vital to navigation, formation keeping, target location, and attack coordination. A type FuG/vaU receiver/transmitter provided high-frequency ship-to-shore radio communication, general reception, and long-range communication.

Maneuvering a Schnellboot in combat required precision navigation and steering under the most trying of conditions. The navigator plotted the course on a small table in the rear of the wheelhouse. Several compasses were carried on board, including a central compass mounted in a binnacle amidships. The captain, navigator, and helmsman had smaller compasses mounted in their respective positions.

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<sup>37</sup> Connelly and Krakow, 2003. A flotilla tender lowers a torpedo onto an S-26 Class Schnellboot in Norway.

Radio Direction Finding (RDF) equipment was standard aboard S-boote. Its distinctive loop antenna fitted into a socket at the rear of the wheelhouse. RDF was used to pinpoint a boat's precise position by triangulating radio transmissions from known positions ashore. A skilled operator could use it to locate the position from which an enemy ship was transmitting.

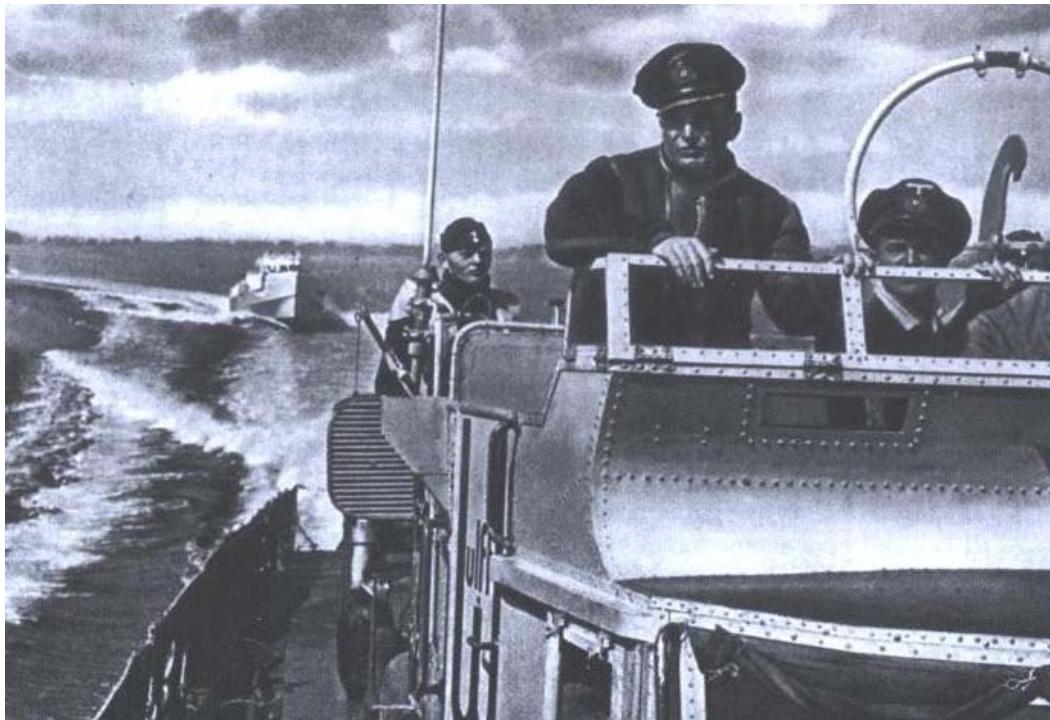


Figure 11. The Schnellboot Formation<sup>38</sup>

Schnellboote relied chiefly on constant radio contact with shore-based radar installations and visual/radio monitoring stations for long distance locations of, and vectors to, enemy ships. Shore-based radar was effective to within 18 km (11 miles) of England's coast in good weather and gained efficiency closer to the occupied coast. In March of 1944, an experimental set designated FuMO 62 "Hohentwiel S" was developed and tested for Schnellboot use. It was based on the Luftwaffe's FuG 200 Hohentwiel anti-

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<sup>38</sup> Connelly and Krakow, 2003. The S-38 Class boat Wulff leads two other S-boote out on patrol. The boat's name is painted on the bridge's side. A radio antenna mast is mounted on the aft starboard section of the bridge. A whimsical wooden parrot decorates the large loop-shaped Radio Direction Finding RDF antenna. The Kommandant wears a captured French fleece jacket. Narrow gold embroidery on his cap visor indicates he was a junior officer between Leutnant ensign and Kapitanleutnant Lieutenant.

surface vessel (ASV) radar. The FuMO 62 had a greater range—approximately 10 km (6.2 miles)—and more accuracy than the FuMO 7. However, the 1.2m (4 feet) by 1.2m rotating antenna caused a similar increase in radar signature.

The German engineers recognized the disparity between the high-quality Allied radar and less than satisfactory German sets. They developed a number of effective radar counter measures, including passive radar detection and ranging. One radar detection system gave early warning of enemy forces based on their radar emissions while an S-boot was still beyond the useful range of the enemy's own radar. The apparatus effectively enabled an S-boot to detect and generally locate the enemy's presence without being located itself. The FuMB Ant 3, code named "Bali 1" antenna was a commonly used passive radar detection sensor. The "Bali 1" antenna was part of the FuMB 29 "Bali Anlage" radar surveillance system. It could be used with a FuMB 4 "Samos" receiver (90-470 MHz), a FuMB 9 frequency indicator (146-264 MHz), or a FuMB 10 "Borkum" signal detector (100-400 MHz). The signals were fed through a booster to a FuMZ 1 oscilloscope, where the operator viewed and interpreted the information.

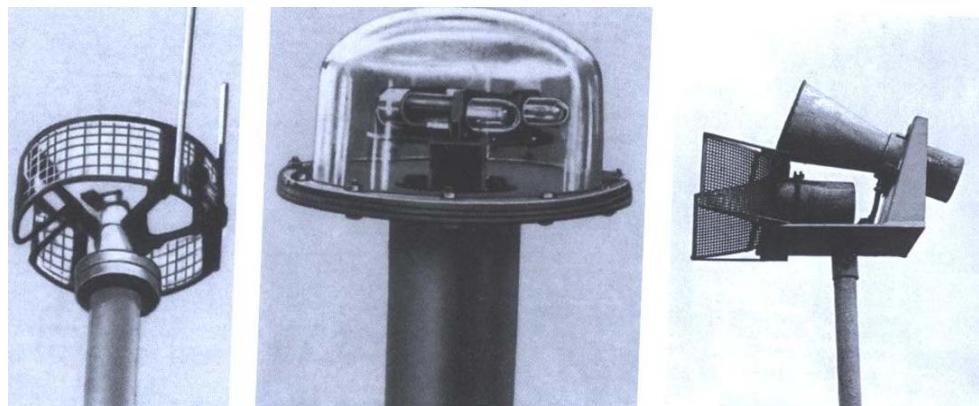


Figure 12. Radar Detector Antennas of Schnellboote<sup>39</sup>

The Germans further exploited the weaknesses of enemy radar by deploying radar decoy buoys, which mimicked a Schnellboot's radar signature to confuse the enemy.

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<sup>39</sup> Connelly and Krakow, 2003. From left to right, the FuMB 32 'Flores' antenna ZA 290M antenna FuMB 26 'Tunis' radar detector antenna.

Other experiments attempted to find materials that would conceal the boats from enemy radar by absorbing or scattering radio signals. A reflection dimming rubberized coating known as “Tarnmatte” (Camouflage Mat) was developed and used by S-boote. Experiments with passive infrared night vision equipment showed great promise, but by the war’s end even the most advanced versions still required a fairly steady platform and clear weather conditions. These rendered the equipment ineffective in fog or on moderate seas. Passive infrared night vision devices were used with success on heavier ships and at land-based observation points.<sup>40</sup>

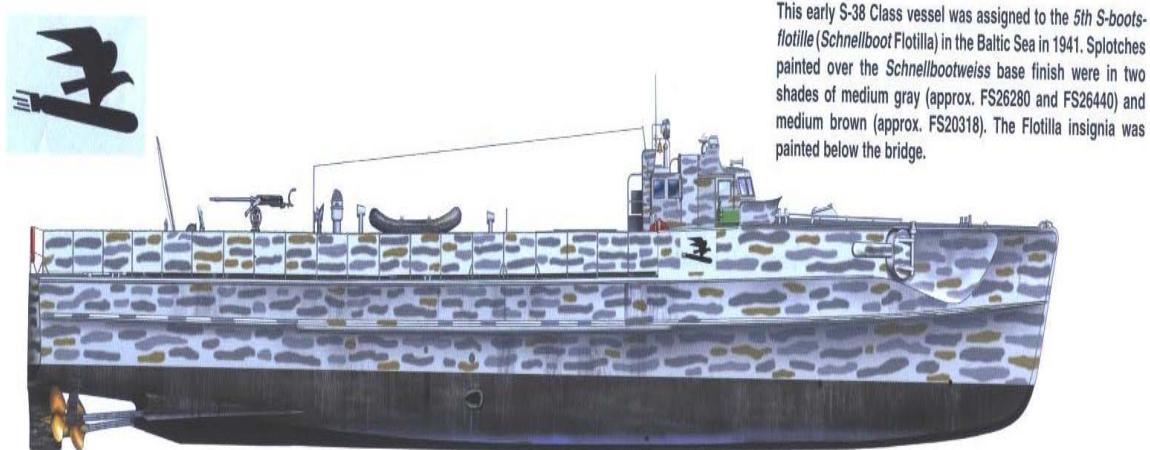


Figure 13. S-38 Class Schnellboot with Camouflage<sup>41</sup>

“It is incomparably more effective to sink a whole cargo than to have to fight the unloaded personnel and material separately on land at a later date.” This was how German Führer (Leader) Adolf Hitler summarized the underlying strategy of Schnellboot operations. Early in the war, Schnellboot captains pressed home many daring close quarters attacks on Allied merchant ships and convoys. Luftwaffe air support enabled them to travel to and from distant ambush areas during daylight hours. These tactics employed against the Western Allies grew more conservative as the Allies’ defenses

<sup>40</sup> Connelly and Krakow, 2003.

<sup>41</sup> Connelly and Krakow, 2003. The Schnellboot is painted in hard-edged splotches of browns and grays over the Schnellbootweiss finish. The camouflage allowed the boat to better match the snow-covered fjord landscape.

became more potent and the Schnellboot flotillas' ranks were thinned. A U.S. Navy intelligence report from June of 1944 (which called S-boote 'E-Boats') summarized Schnellboot operations as follows:

E-Boats favor night conditions of mist and calm sea luminous conditions such as a half moon. They leave their bases in packs and on reaching the convoy lanes, split into flotillas of six. Boats with the 40 mm [cannon] take stern positions in formation. They move in column formation and are generally given accurate radar information from shore. Using hydrophones and elementary radar, they move slowly and quietly up for attack (they may lay quiet moored to a Channel buoy) and after firing their torpedoes use evasive tactics similar to PTs (U.S. Patrol Torpedo boats). The flotilla leaders decide the tactics, and their policy up to the present has been to avoid combat. These boats attack British small craft only if the prey is crippled or vastly inferior in firepower.



Figure 14. S-38 Class Schnellboot before a Mission<sup>42</sup>

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<sup>42</sup> Connelly and Krakow, 2003. Sailors prepare an S-38 Class Schnellboot for a mission in the Gulf of Finland. A depth charge is lowered to the boat from the flotilla tender while crewmen attach mine rails to the decks.

E-Boats are high speed torpedo boats; neither hull nor armaments are capable of resisting the slower British boats. Committed to a policy of conservation of their numbers, they decline gunnery duels. They shadow stragglers or damaged boats, make quick runs and break away, and even conclusive superiority recently has failed to lure them into point blank range. Their marksmanship is mediocre unless given a point of fire by long bursts of tracers. They fire high and often fail to close to effective range before firing.

British craft cannot catch them and rarely attempt a running fight with them. When countered, E-Boats usually run in formation on the flotilla leader, turning away by a ship movement to right or left from column. When circumstances force them to scatter, they apparently have a prearranged rendezvous at certain bearing and distance from any scramble.<sup>43</sup>

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<sup>43</sup> Connelly and Krakow, 2003.

## IV. THE U.S. NAVY LITTORAL COMBAT SHIP (LCS)

Generally, in battle, use the normal force (direct approach) to engage; use the extraordinary (indirect approach) to win.

Sun Tzu, *The Art of War*

### A. LCS OVERVIEW

The U.S. has surface combatants, aircraft carriers, submarines, and amphibious ships. Historically, surface combatants have accounted for 30% to 40% of the U.S. Navy's combatants. At the end of FY2005, they accounted for about 35% (99 of 282 battle force ships). From World War II until the 1980s, surface combatants were viewed largely as defensive escorts for protecting Navy surface ships (i.e., aircraft carriers, amphibious ships, and auxiliary ships) and commercial cargo vessels. During this period, the primary missions of surface combatants were anti-air warfare (AAW) and anti-submarine warfare (ASW), and designs for Navy surface combatant classes were determined in large part by decisions as to whether a given class should emphasize AAW, ASW, or both. The largely escort-oriented role of Navy surface combatants changed in the 1980s with the advent of three major new systems—the Tomahawk cruise missile, the vertical launch system (VLS), and the Aegis combat system.

The capabilities of Navy surface combatants are currently being enhanced by new networking systems such as the Cooperative Engagement Capability (CEC) for air-defense operations. Networking systems like these enable surface combatants, other ships, and aircraft to share large amounts of targeting-quality data on a rapid and continuous basis, permitting them to engage in what is called network-centric warfare (NCW).

The capabilities of surface combatants will be enhanced in the coming years by the addition of unmanned air, surface, and underwater vehicles electromagnetic rail guns, directed-energy weapons such as lasers and improved equipment for detecting and countering mines. Some of these developments will be enabled by the application of advanced, integrated electric drive propulsion technology to surface combatants. As these

developments unfold, surface combatants will likely continue to play a greater role in the defense of both themselves and other friendly surface ships against enemy submarines, surface ships, aircraft, and anti-ship cruise missiles.<sup>44</sup>

On November 1, 2001, the Navy announced that it would issue a revised Request for Proposal (RFP) for its future surface combatant program. Formerly known as DD-21 (for 21<sup>st</sup>-Century Destroyer), the new program would be known as “DD(X),” and it would comprise a family of three new ships: a large multi-mission destroyer from which the family took its name, DD(X); a large multi-mission guided missile cruiser, CG(X); and a small “focused mission” Littoral Combat Ship, or LCS. For the next several decades, these three new “advanced technology surface combatants” will operate alongside a large “legacy” force of over 80 multi-mission combatants designed during the Cold War for open-ocean warfare against the Soviet Navy.

The inclusion of the small focused mission LCS in the new DD(X) family of ships represented an abrupt reversal in the Navy’s plans for its 21<sup>st</sup>-century fleet. In a report forwarded to the U.S. Congress in March 2000, which outlined the Navy’s 30-year plan for shipbuilding, the U.S. Navy had pointedly rejected the potential contribution of small combatants in its future battle force. Indeed, the report indicated that the *smallest* combatant in the 21<sup>st</sup> -century Navy would have a displacement on the order of about 9,000 tons—over three times the size of current LCS designs.<sup>45</sup>

The LCS in some ways is reminiscent of a concept for a small, fast Navy surface combatant called the Streetfighter. The Streetfighter study effort began in 1998 and was centered at the Naval War College. It was led by Vice Admiral Arthur Cebrowski, who became the President of the college that year. In the late 1990s Cebrowski helped to develop and publicize the concept of network-centric warfare, and emerged as a leading proponent of naval transformation. He retired from the Navy in 2001. From October

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<sup>44</sup> O'Rourke and Library of Congress. Congressional Research Service, 2005.

<sup>45</sup> Work and Center for Strategic and Budgetary Assessments Washington, D.C., 2004.

2001, a month prior the replacement of the DD-21 program with the DD(X) family of ships, through January 31, 2005, he served as the civilian director of the DOD's Office of Force Transformation.

The Streetfighter study was aimed at generating new naval concepts for fighting in heavily defended littoral waters. The Streetfighter concept for a small, fast surface combatant, unveiled publicly in 1999, generated significant debate. Supporters viewed it as innovative, transformational, and responsive to the U.S. Navy's needs for affordable, littoral-oriented forces. Critics doubted the feasibility of combining high speed, overseas sustainability, and significant payload in a small ship, as well as the ability of a small ship to survive in combat. The U.S. Navy officials allowed the Streetfighter project to proceed, but most navy leaders at the time appeared to resist the idea of a smaller combatant. Although U.S. Navy officials have emphasized that the LCS is not the Streetfighter proposal of 1999-2001, the LCS—in terms of its littoral orientation, smaller size, high speed, and planned reliance on UVs—does appear broadly rooted in some of the thinking that came out of the Streetfighter project.<sup>46</sup>

In December 2001, the Naval War College was asked to develop and define characteristics that would be desirable in a littoral combat ship. The college used a series of workshops that included operational and technical experts from throughout the Navy to compare three types and sizes of surface combatant ships and describe desirable characteristics that such a ship should have. The experts examined such characteristics as speed, range, manning, and the ability to operate helicopters and unmanned vehicles. The workshop participants also concluded that a potential littoral ship should:

- be capable of networking with other platforms and sensors;
- be useful across the spectrum of conflict;
- be able to contribute to a sustained, forward naval presence;
- be capable of supporting manned vertical lift aircraft;
- be capable of operating with reduced manning;
- have an open architecture and modularity;

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<sup>46</sup> O'Rourke and Library of Congress. Congressional Research Service, 2005.

- be capable of controlling manned and unmanned vehicles, and
- have organic self-defense capabilities.

The results of the Naval War College study, which was completed in July 2002, were used as a baseline for further developing the concepts for the LCS.

At this point the U.S. Navy's analysis was focused on a single solution to address littoral capability gaps—a new warship along the lines of the LCS. Between April 2002 and January 2004, the Navy conducted an analysis of multiple concepts to further define the concept that would address the gaps in the littorals. The analysis began by examining five different ship concepts for the LCS (later focusing on three concepts for another stage in the development) and providing the Navy with insight into the trade-offs between features such as size, speed, endurance, and self defense needs. The analysis was performed by the U.S. Naval Surface Warfare Center, Dahlgren Division, and drew upon expertise throughout the Navy.

The Office of the Secretary of Defense and the Joint Staff were concerned that the Navy's focus on a single solution did not adequately consider other ways to address littoral capability problems. Based on these concerns, in early 2004, the Navy was required to more fully consider other potential solutions. The publication of new guidance on joint capabilities development in June 2003 also led the Navy to expand its analysis beyond the single solution of the proposed new ship to include other potential solutions to littoral challenges.<sup>47</sup>

As part of the results from the analysis, the U.S. Navy defined littoral capability problems, developed requirements to address those problems, and identified and examined 11 nonmateriel and three materiel solutions across the joint forces that could be used to mitigate problems in the littorals. Nonmateriel solutions refer to the use of different operational concepts or methods to meet requirements without buying new assets such as additional ships; materiel solutions are those which involve developing equipment or systems, such as ships and aircraft. The solutions were analyzed to determine the feasibility and risk in mitigating the problems. The Navy's assessment of

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<sup>47</sup> O'Rourke and Library of Congress. Congressional Research Service, 2005.

feasibility centered on the extent to which each solution addressed the mine, anti-submarine, and surface capability problems. The Navy's assessment of risk centered on the impacts of each solution on (1) the success of potential operations in the littorals, (2) the sensitivity of diplomatic considerations, such as the military support of other nations, and (3) the financial considerations involved in choosing that solution.

Two additional materiel solutions were maritime patrol aircraft and modified DDG-51 destroyers. These resulted from the U.S. Navy's analysis as a result of input from the Office of the Secretary of Defense's Program Analysis and Evaluation office and the Acquisition, Technology and Logistics office. The Office of the Secretary of Defense and the Joint Staff also provided specific questions to the Navy for further clarification of the Navy's ongoing analysis. With these additions, the Program Analysis and Evaluation office approved the Navy's completed analysis as satisfactory to meet the requirements of a full analysis of alternatives for the LCS program. Table 4 shows the materiel and nonmateriel solutions presented in the Navy's requirements analysis and the results of the U.S. Navy's analysis of operational feasibility, as well as operational, diplomatic, and financial risk.<sup>48</sup>

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<sup>48</sup> United States Government Accountability Office, 2005.

Nonmateriel solutions	Gap mitigation	Overall feasibility	Navy's risk assessment
Use existing force structure (Combination of assets from carrier and expeditionary strike groups)	Significant antisubmarine, surface, and mine warfare mitigation	Partially feasible	Some operational risk Negligible financial risk Negligible diplomatic risk
Use existing force structure (independent submarines)	Significant antisubmarine mitigation; partial mine warfare mitigation; little to no surface warfare mitigation	Partially feasible	Some operational risk Negligible financial risk Negligible diplomatic risk
Use existing force structure (maritime patrol aircraft and helicopters)	Significant antisubmarine and surface warfare mitigation; partial mine warfare	Partially feasible	Some financial risk Some diplomatic risk Some operational risk
Use existing force structure (Land based tactical aviation for surface warfare)	Little to no antisubmarine and mine warfare mitigation; partial surface warfare	Not feasible	Significant diplomatic risk Some operational risk Some financial risk
Use existing force structure (Long range bombers)	Little to no antisubmarine, mine, and surface warfare mitigation	Not feasible	Significant operational risk Some financial risk Some diplomatic risk
Use existing force structure (Theater-national overhead systems)	Little to no antisubmarine, mine, and surface warfare mitigation	Not feasible	Significant operational risk Negligible diplomatic risk Negligible financial risk
Assign mission to nonmilitary force	Little to no antisubmarine and mine warfare mitigation; partial surface warfare mitigation	Not feasible	Significant operational risk Some financial risk Some diplomatic risk
Not entering contested littorals	Little to no antisubmarine, mine, and surface warfare mitigation	Not feasible	Significant operational risk Significant diplomatic risk Some financial risk
Preemptive actions to eliminate threat	Partial antisubmarine, mine, and surface warfare mitigation	Not feasible	Significant operational risk Significant diplomatic risk Negligible financial risk
Assign tasks to coalition partners	Partial antisubmarine, mine, and surface warfare mitigation	Partially feasible	Significant operational risk Significant diplomatic risk Some financial risk
Tolerate capability gaps (Accept risk)	Little to no antisubmarine, mine, and surface warfare mitigation	Not feasible	Significant operational risk Significant diplomatic risk Negligible financial risk

Table 4. The U.S. Navy's Comparison of Materiel and Nonmateriel Solutions for Mitigating Problems in the Littorals<sup>49</sup>

Based on its analysis, the U.S. Navy concluded that the materiel and nonmateriel solutions they examined would not provide better operational and cost-effective solutions than the proposed LCS in performing the littoral missions. Using a number of studies of threats and analyses of potential military operations in the littoral regions, the U.S. Navy developed requirements for the LCS that addressed the identified capabilities and threats in the littorals.

The LCS will be a modular ship. The platform will support mine warfare, anti-submarine warfare, and anti-surface boat modules. The LCS concept is presently being

<sup>49</sup> United States Government Accountability Office, 2005.

defined and is envisioned to be an advanced hullform employing open-systems architecture modules to undertake a number of missions and to reconfigure in response to changes in mission, threat, and technology.<sup>50</sup>

According to the LCS Naval Sea Systems Command (NAVSEA) Program Manager Captain Donald Bancock, U.S. Navy, the development and employment of the LCS is like “playing with LEGO’s.” The core will stand by to receive additional blocks (modules). The actual mission modules will be delivered in standard-sized cargo containers. These containers are lowered through a door in the flight deck into the mission module area. The Interface Control Document (ICD) for the LCS states:<sup>51</sup>

The LCS platform shall be designed to accommodate multiple reconfigurable modular mission packages to accomplish focused missions via an open and modular design that provides flexibility and ease of upgrade while ensuring rapid and successful installation and integration of the mission packages to the platform. To permit use of a wide range of both present and future mission systems and to permit platform and mission systems to be developed independently, a standard interface in the form of a standard technical architecture must be used. The industry shall design and build the LCS platform, employing an open modular architecture for mission systems based on this standard technical architecture. Separately, mission modules will be developed for the LCS based on this technical architecture.<sup>52</sup>

The LCS is less of a ship and more of a battle network component system consisting of a sea frame, a core crew, assorted mission modules, assembled mission packages, mission package crews, and a reconfiguration support structure. The total system aims for a level of battle modularity that will allow the LCS to undergo a complete mission reconfiguration in less than four days including operational testing of its combat systems and crew readiness. If successfully demonstrated, the LCS’s high

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<sup>50</sup> Global Security Org., 2006.

<sup>51</sup> Bromley, 2005.

<sup>52</sup> Naval Sea Systems, 2004.

degree of modularity would be without precedent in naval history, and would afford a 21<sup>st</sup> century total force to adapt itself to confront any existing or evolving access challenge in a short period of time.<sup>53</sup>

On May 27, 2004, the U.S. Department of Defense announced that Lockheed Martin Corporation - Maritime Systems & Sensors, Moorestown, N.J. (\$46,501,821) and General Dynamics - Bath Iron Works, Bath, Maine (\$78,798,188) were each awarded contract options for final system designs with options for detailed design and construction of up to two phase 0 Littoral Combat Ships (LCS).

Of the two competing designs, the Lockheed design is a high-speed semi-planing monohull, while the General Dynamics design is a slender, stabilized monohull, more commonly known as a trimaran. Each of these meets the performance requirements of the top-level requirements documents and achieves advantages in several key performance parameters.

Both designs achieve sprint speeds of over 40 knots as well as long-range transit distances of over 3,500 miles. The sea frames of each design can accommodate the equipment and crews of the focus mission packages and effectively launch, recover and control unmanned vehicles for extended periods of time in required sea states. The methods by which each launch and recover both aircraft and waterborne craft are different.<sup>54</sup>

The U.S. Navy plans to procure a total of 55 LCSs. The first was ordered in FY2005, and three more are being ordered in FY2006. The FY2005 ship and one of the FY2006 ships were procured through the Navy's research and development account. The other two FY2006 ships and all subsequent LCSs are being procured through the Shipbuilding and Conversion, Navy (SCN) appropriation account. The Navy's FY2007-FY2011 shipbuilding plan includes two LCSs in FY2007, three in FY2008, and six per year in FY2009-FY2011.

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<sup>53</sup> Work and Center for Strategic and Budgetary Assessments, Washington, D.C., 2004.

<sup>54</sup> Global Security Org., 2006.

Table 5 shows LCS funding through FY2011. The Navy's FY2007 budget submission estimates the total procurement cost of a class of 56 (not 55) LCS sea frames at about \$17.6 billion in then-year dollars. Using the figures in Tables 5 and 6, when other LCS program costs are included, the LCS program could have a total acquisition (development plus procurement) cost of more than \$26 billion, or more than \$470 million per ship, in then-year dollars.<sup>55</sup>

	03	04	05	06	07	08	09	10	11	Total thru FY11
<b>Research, Development, Test &amp; Evaluation, Navy (RDT&amp;EN) account</b>										
Ship 1 construction	0	0	206.7	59.2	8.5	0	0	0	0	274.5
Ship 2 construction	0	0	16.0	207.1	55.0	0	0	0	0	278.1
Ships 3-27 out-fitting/post delivery	0	0	0	8.7	36.7	36.8	7.1	0	0	89.3
LCS ship development	35.3	160.1	228.0	86.0	57.0	60.3	43.2	43.9	22.4	736.2
LCS mission package project (qty)	0	0	0	213.0	162.3 (3)	90.4 (1)	82.5	100.1	40.8	689.2
<b>Subtotal RDT&amp;EN</b>	<b>35.3</b>	<b>160.1</b>	<b>450.8</b>	<b>574.0</b>	<b>319.6</b>	<b>187.6</b>	<b>132.8</b>	<b>144.1</b>	<b>63.2</b>	<b>2067.3</b>
<b>Shipbuilding and Conversion, Navy (SCN) account</b>										
Ships 3-27, (qty)	0	0	0	440.0 (2)	520.7 (2)	947.6 (3)	1764.3 (6)	1774.2 (6)	1825.4 (6)	7272.3 (25)
<b>Subtotal SCN</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>440.0</b>	<b>520.7</b>	<b>947.6</b>	<b>1764.3</b>	<b>1774.2</b>	<b>1825.4</b>	<b>7272.3</b>
<b>Other Procurement, Navy (OPN) account (for LCS mission modules)</b>										
<b>Subtotal OPN (qty)</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>40.1 (0)</b>	<b>79.1 (1)</b>	<b>207.6 (3)</b>	<b>652.3 (13)</b>	<b>656.2 (12)</b>	<b>720.2 (15)</b>	<b>2355.5 (44)</b>
<b>Weapons Procurement, Navy (WPN) account</b>										
<b>Subtotal WPN</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>12.5</b>	<b>39.1</b>	<b>91.0</b>	<b>134.2</b>	<b>276.8</b>
<b>TOTAL</b>	<b>35.3</b>	<b>160.1</b>	<b>450.8</b>	<b>1054.1</b>	<b>919.3</b>	<b>1355.3</b>	<b>2588.5</b>	<b>2665.6</b>	<b>2743.0</b>	<b>11971.9</b>

Table 5. The Funding for LCS Program, FY2002–FY2011<sup>56</sup>

FY	DD(X)	CG(X)	LCS	DDG(X)
07	2		2	
08			3	
09	1		6	
10	1		6	
11	1	1	6	
12	1		6	
13	1	1	5	
14		1	6	
15		2	6	
16		1	5	
17		1		

<sup>55</sup> O'Rourke and Library of Congress. Congressional Research Service, 2006.

<sup>56</sup> U.S. Navy Office of Legislative Affairs, 2006.

<b>FY</b>	<b>DD(X)</b>	<b>CG(X)</b>	<b>LCS</b>	<b>DDG(X)</b>
18		2		
19		2		
20		2		
21		2		
22		2		
23		1		1
24				2
25				2
26				2
27				2
28				2
29				2
30			1	2
31			1	2
32			2	2
33			3	2
34			6	2
35			6	2
36			4	2

Table 6. Projected Procurement of Surface Combatants, FY2007–FY2036<sup>57</sup>

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<sup>57</sup> U.S. Department of the Navy, 2006.

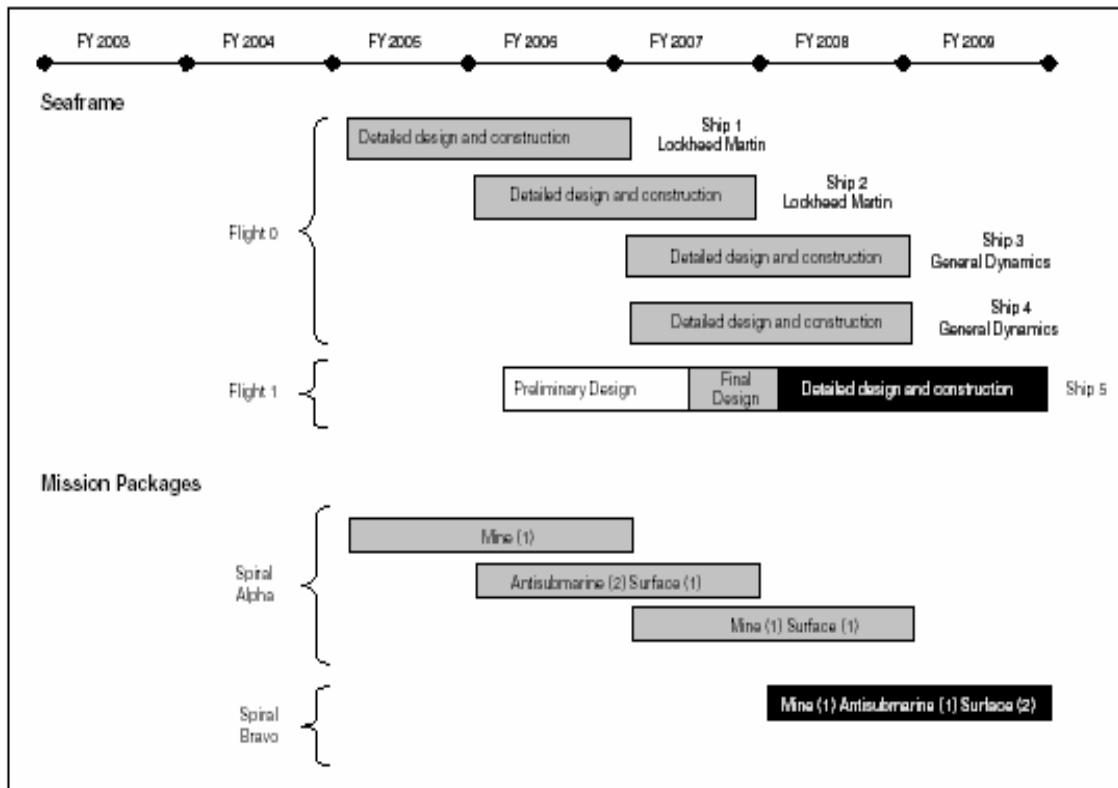


Table 7. LCS Acquisition Timeline<sup>58</sup>

## B. LITTORAL COMBAT SHIP CORE CAPABILITIES

The Littoral Combat Ship is a magnificent concept. It is a critical element of U.S. surface combatant family of ships, which also includes DD(X) destroyer, the CG(X) cruiser, and fleet of multi-mission AEGIS guided-missile destroyers and cruisers. The Complementary capabilities of these transformational warships will be successful across the full spectrum of operational requirements demanded of surface force for years to come.

Rear Admiral Mark Edwards  
Director of Surface Warfare on the Navy Staff

Mission requirements for the LCS program are technically covered (i.e., “grandfathered”) by the MNS that was issued for the old SC-21 (i.e., DD-21) program. The analysis behind the SC-21 MNS, however, did not focus on potential anti-access challenges in littoral waters. The U.S. Navy’s requirement for additional capability for countering enemy submarines, surface attack craft, and mines in littoral waters is based

<sup>58</sup> United States Government Accountability Office, 2005.

on an analysis that the Navy performed initially in February 2001, which did focus on potential anti-access challenges in littoral waters, and was aimed at identifying gaps or weakness in the capabilities of the Navy. The Navy refined this analysis further in 2001 and 2002 and then issued mission requirements for the LCS in a preliminary design interim requirements document.<sup>59</sup> The document states:

The primary threat to sea based U.S. joint forces will be from mines, aircraft, ships, boats, submarines, and coastal defense units armed with Anti-Ship Cruise Missiles (ASCM) and submarine-launched torpedoes. Mines present the most challenging threat because they can be deployed from ships and aircraft, both military and civilian, and can also be deployed from submarines. Significant threats will also come from air and ship launched torpedoes; fighter-launched Tactical Air-to-Surface Missiles; other ordnance carried by sea and land-based aircraft (fixed- and rotary-wing); chemical, biological, and nuclear weapons; and in the future, directed energy weapons. While operating in the littoral regions, additional threats from coastal defense sites (artillery, missile, multiple rocket launchers, and possibly torpedoes,) small boats, and Tactical Ballistic Missiles may be encountered. A third tier threat will include preemptive attacks or covert action from special operations forces, combat divers, and terrorists. The weapons threats may be supported by C3 [command, control, and communications], electronic attack, and electronic support [i.e., electronic eavesdropping] systems.

The LCS will deliver focused mission capabilities to enable joint and friendly forces to operate effectively in the littoral. These focused mission capabilities are an enhanced mine warfare capability, a better shallow-water ASW capability, and an effective counter to small craft. There are other capabilities inherent in the LCS that support other missions such as Maritime Interdiction Operations (MIO) and Intelligence, Surveillance, and Reconnaissance (ISR).

While operating in open waters, warships count on the inherent difficulties in scouting such vast areas to conceal their positions. Most countries lack reconnaissance and surveillance capabilities to detect and localize the U.S. Naval Forces far out at sea. This changes, however, if U.S. Naval Forces move closer to the enemy's coast to conduct littoral sea control, protect friendly or neutral merchant shipping, or bring targets ashore

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<sup>59</sup> U.S. Department of the Navy, 2003.

within range of the U.S. Navy's power projection. Having to fight in the enemy's neighborhood can offset the U.S. advantages in training and equipment, as it drastically simplifies enemy scouting, logistics, force-concealment, and weapon-range problems. Contemporary mines, diesel/air-independent-propulsion submarines, fast guided-missile patrol boats, land-based aircraft, and coastal anti-ship cruise missile (ASCM) sites present the naval forces with a conventional multiaxis, multiple warfare area problems and the threat grows the closer the U.S. Naval Forces steam toward maritime choke points or the coast. In addition, small boats pose an unconventional threat when used for harassment, attack by light standoff weapons such as rocket-propelled grenades, or the delivery of explosive devices. They limit the U.S. Naval Forces ability to quickly determine the threat posed by a contact. Such attacks are easily conducted in coastal waters, and if the attackers are of sufficient number, they can saturate and overwhelm a force's defenses.<sup>60</sup>

The LCS was designed to succeed in spite of these threats. Its modular design, which permits mission-oriented outfitting, and small size will allow the LCS squadrons to fight where the U.S. would not risk an expensive major combatant during the first days of combat. The risk, though, is that the fast, lightweight, heavily armed, and relatively inexpensive LCS will start growing in size, displacement, and expense as pet missions and extraneous capabilities are added beyond the original concept.<sup>61</sup>

The LCS is about taking the fight into the enemy's home waters – the shallow waters that wreak havoc on long-range Cold War-era sonar; waters with dense maritime traffic that can challenge the building and maintenance of a recognized maritime picture and blur the lines between friend and foe; and tactically complex waters that provide shallow-draft warships excellent locations for scouting, attacking, and concealment.

The LCS is not another ship for the battle group; it is not appropriate for screening carriers. It is not intended for area air defense of forces ashore, deep strikes inland with cruise missiles such as the Tomahawk, logistics transportation, or floating

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<sup>60</sup> Solomon, 2004.

<sup>61</sup> Solomon, 2004.

medical care. It cannot house the communications suite and does not have the space required for a forward command-and-control center. Troops ashore will be best supported by extended-range naval gunfire from ships with the proposed advanced gun system and follow-on electromagnetic rail guns, not the LCS.

What the LCS will do is open the door that permits putting those troops ashore. If the U.S. wants a ship that can counter the many asymmetric threats the U.S. faces now and expects to face in the future in coastal waters, the LCS must be built as an advance scout and hunter/killer for a battle force in high-threat environments, and as an interdictor and raider in low- and intermediate-threat environments. It operates most effectively when it is part of a fully networked LCS squadron that masses the capabilities of its combined sensors and weapons across all threat warfare areas.<sup>62</sup>

### **C. WEAPON SYSTEMS AND MISSION PACKAGES FOR THE LITTORAL COMBAT SHIP**

For anti-surface warfare, a coastal combatant is best armed when it has sufficient anti-ship missiles to saturate and achieve firepower kill against threat warships. Harpoon canisters could be enclosed within a low-RCS box launcher outside the ship's skin that conforms to the ship's overall physical profile. However, Harpoon is not appropriate for all threats and is overkill against small vessels.

The NATO Sea Sparrow has an excellent anti-surface capability, and with the upcoming introduction of the Evolved Sea Sparrow Missile (ESSM) would be a suitable weapons choice. An advantage of the ESSM is that it was engineered for the vastly differing combat systems of multiple nations' warships – it is built to be adaptable.

As Aegis is too big and excessive for the LCS mission, the LCS requires a new search radar with the ability to automatically track many low-RCS contacts at all altitudes; particularly those at low elevations. It also must be fully integrated with the LCS combat system and capable of automatically detecting and engaging threats at ranges that permit reengagement if the first defensive salvo fails.

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<sup>62</sup> Solomon, 2004.

A large inventory of standoff active electronic countermeasures, such as the NULKA decoy system, and traditional passive countermeasures, such as chaff and flares, will round out the LCS's shield against advanced ASCMs.

Undersea threats present the greatest challenge to the LCS. The shallow water column, high ambient noise, and amount of debris near a coastline complicate the acoustic problem for littoral anti-submarine warfare. Lower-frequency active sonar, such as the legacy AN/SQS-53 series, suffer from reverberation in waters like these. The LCS needs small, hull-mounted, high-frequency active sonar for mine avoidance.<sup>63</sup>

Tables 8 and 9 show anti-submarine warfare and surface warfare mission packages status.

Mission package systems	Role	Mature	Available in FY 2008	Issues
Unmanned surface vehicle & sensor systems	Detect	No	Unknown	Still in development
Advanced deployable system	Detect	No	Yes	Still in development
Remote mine-hunting vehicle & sensor systems	Detect	No	Unknown	Still in development
MH-60 R helicopter		Yes	Unknown	Schedule risk
• Mk 54 torpedo	Neutralize	Yes	Unknown	Linked to helicopter
• Airborne low frequency sonar	Detect	Yes	Unknown	Linked to helicopter
• Sonobuoys	Detect	Yes	Unknown	Linked to helicopter
Torpedo countermeasures on ship	Defense	No	Yes	
Vertical takeoff unmanned aerial vehicle & communications equipment	Communications	No	Unknown	Still in development

Table 8. Anti-submarine Warfare Mission Package Status<sup>64</sup>

Mission package systems	Role	Mature	Available in FY 2008	Issues
Unmanned surface vehicle & electro-optical infrared sensors	Detect	No	Unknown	Still in development
• 30mm gun system	Neutralize	No	Yes	Still in development
• NeilFires Missile System	Neutralize	No	Yes	Still in development
• Running gear entanglement system	Neutralize	No	Yes	Still in development
Vertical takeoff unmanned aerial vehicle & electro-optical infrared sensors	Detect	No	Yes	Still in development
MH-60 R helicopter & sensor systems	Detect	No	Unknown	Schedule risk
• GAU 16 gun system	Neutralize	No	Unknown	Linked to helicopter
• Hellfire	Neutralize	Yes	Unknown	Linked to helicopter
NetFires missile system on ship	Neutralize	No	Yes	Still in development
30mm gun system on ship	Neutralize	No	Yes	Still in development

Table 9. Surface Warfare Mission Package Status<sup>65</sup>

<sup>63</sup> Solomon, 2004.

<sup>64</sup> United States Government Accountability Office, 2005.

<sup>65</sup> United States Government Accountability Office, 2005.

More than 350,000 sea mines are estimated to be stockpiled around the world. Surf-zone mines, shallow-water mines, deep-water mines, moored mines, bottom mines, floating mines, rising mines, and mines deployed from unsophisticated or cleverly configured ships and barges (as evidenced during Operation Iraqi Freedom) are part of an array of threats. As the U.S. Navy and Marine Corps refine the concept of sea basing in support of joint forcible entry, littoral mine counter measure (MCM) capability will become increasingly important.

The U.S. current mine warfare force consists of 14 Avenger-class (MCM- 1) minesweepers, 12 Osprey-class (MHC-51) coastal mine hunters, and two squadrons of MH-53E helicopters. As the organic mine warfare systems reach their initial operating capability and enter the U.S. fleet in adequate numbers, legacy mine warfare forces can begin to be retired. Osprey-class mine hunters are the least capable of the U.S. mine warfare ships and could be retired first. They may be of use to U.S. allies in the Persian Gulf and western Pacific where there will be significant mine threats.

The LCS's mine warfare mission package (Table 10) will include mine-hunting, minesweeping, and mine-neutralizing systems. Mine hunting locates and identifies mines for neutralization. Minesweeping does not identify individual mines, but puts acoustic and magnetic energy into the water to fulfill the target detection parameters and detonate any mines in the swept area. If warning time were available, the submarine-launched long-term mine reconnaissance system (or follow-on mission reconfigurable unmanned underwater vehicles) could conduct covert surveys of transit routes and potential joint-operating areas to determine the presence and location of minefields. Depending on the size of the suspected minefield or area to be cleared, one or more LCSs with mine-warfare mission packages would be vectored to the area. Standing a safe distance from the suspected minefield, the MH-60S helicopter would be launched with the airborne laser mine detection system (ALMDS) to provide a rapid, broad-area search for surface- or near-surface-moored mines. As areas closest to the ship are searched, remote mine-hunting vehicles (RMVs) would be launched towing the AQS-20A mine-hunting sonar. RMVs will perform better than helicopters in this role because of their persistence (longer than 14-hour mission time) and ability to work around the clock. (The MH-60S

mission time is less than two hours when towing the AQS-20A, and few helicopter pilots relish the opportunity to fly at 100 feet, at night, with a nose-down attitude, and with the out-of-balance flight required for towing.) Future unmanned underwater vehicles (UUVs) also might fill a mine-hunting role.

In areas unsuitable for mine hunting, or if rapid mine clearance is required, unmanned surface vehicles (USVs) and the MH-60S could tow the organic airborne-surface-influence and acoustic minesweeping system. As with RMVs towing the AQS-20A, USVs are more suitable for sweeping because their mission duration is significantly longer than an MH-60S helicopters in the tow mode, and because USVs can tow around the clock.<sup>66</sup>

A full load displacement draft of 10 feet allows the LCSs to access very shallow waters. The ships will have a top speed of about 50 knots and the range at sprint speed is 1,500 nm. At an economical speed of 20 knots, the range is 4,300 nm.

The LCSs are configured with a helicopter deck and hangar. The deck is capable of the launch and recovery of the MH-60R/S helicopter and a tactical unmanned air vehicle. The ships can carry out aircraft launch and recovery in conditions up to Sea State 5, i.e., in winds up to 27 knots and average wave heights between 6.4 ft. and 9.6 ft. The ships will be capable of launching and recovering watercraft, i.e. 40 ft. high-speed boats, within 15 minutes in conditions of Sea State 4, i.e., waves up to 5 ft. and winds up to 21 knots.

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<sup>66</sup> Ryan, 2004.

Mission	Role	Mature	Available in FY 2007	Issues
Vertical takeoff unmanned aerial vehicle & Coastal battlefield reconnaissance analysis system	Detect	No	Yes	Still in development
Remote mine-hunting vehicle & AQS-20A sonar	Detect	Yes	Yes	May require alterations
Battlefield preparation autonomous underwater vehicle	Detect	Yes	Yes	Has performance problems
Sculpin undersea autonomous vehicle	Detect	Yes	Yes	
MH-60s helicopter		No	Unknown	Schedule risk
• AQS-20A sonar	Detect	Yes	Unknown	Linked to helicopter
• Airborne laser mine detection system	Detect	Yes	Unknown	Linked to helicopter. Only system for detecting floating mines in shallow water
• Rapid airborne mine clearance system	Neutralize	Yes	Unknown	Linked to helicopter
• Organic airborne surface influence sweep system	Neutralize	No	Unknown	Linked to helicopter
• Airborne mine neutralization system	Neutralize	No	Unknown	Linked to helicopter
Unmanned surface vehicle & influence sweep system	Neutralize	No	Unknown	Still in development
Navy mine clearance team	Neutralize	Yes	Yes	Still in development

Table 10. Mine Warfare Mission Package Status<sup>67</sup>

The ships will carry provisions for 21 days before replenishments and will also be able to replenish underway. The crew size will be between 15 and 50 and accommodation will be provided for up to 75 ship and special mission crew. The operational availability is expected to be 95%.

The ship has core capabilities for defense and network communications. They will be equipped with radar and sonar sensors. Core capabilities will include the deployment of a Fire Scout Unmanned Air Vehicle, the AQS-20 towed mine-hunting multiple beam sonar a unmanned ribbed boat and the Spartan Unmanned Surface Vehicle that is equipped with a basic payload of navigation radar, infrared camera, and video camera. Other payloads being considered for the Spartan include an anti-surface warfare (ASuW) missile system or a gun and anti-submarine warfare (ASW) mine-hunting sonar.<sup>68</sup>

#### D. LITTORAL COMBAT SHIP PRIMARY MISSIONS

The LCS primary missions are those that ensure and enhance friendly force access to littoral areas. Access-focused missions include the following primary missions:

- Anti-surface warfare (ASuW) against hostile small boats
- Mine Counter Measures (MCM)
- Littoral Anti-Submarine Warfare (ASW)

<sup>67</sup> United States Government Accountability Office, 2005.

<sup>68</sup> Naval Technology Web Page, 2006.

- Intelligence, Surveillance, and Reconnaissance (ISR)
- Homeland Defense / Maritime Intercept
- Special Operations Forces support
- Logistic support for movement of personnel and supplies.<sup>69</sup>

The packages for these primary missions will enable the LCS to:

- Detect, classify, and identify surface, moored, and bottom mines in order to permit maneuvering in or use of selected sea areas.
- Coordinate/support mission planning and execution with joint and combined assets in the absence of dedicated mine warfare (MW) command and control platforms. MW mission planning will include the use of organic and remotely operated sensors. The LCS will exchange MW tactical information including Mine Danger Areas (MDA), mine locations, mine types, environmental data, bottom maps, off-board system locations, planned search areas and confidence factors.
- Conduct mine reconnaissance.
- Perform bottom mapping.
- Perform minefield breakthrough punch-through operations using off-board systems.
- Perform minesweeping using off-board mission system.
- Conduct precise location and reporting of a full range of MCM contact data. For example: identify mines and non-mine bottom objects.
- Perform mine neutralization.
- Employ, reconfigure, and support MH-60S for MW operations.
- Deploy an EOD detachment.
- Deploy, control, and recover off-board systems, and process data from off-board systems.
- Conduct integrated surface surveillance using onboard and off-board sensors.
- Discriminate and identify friendly and neutral surface vessels from surface enemy threats in high-density shipping environments.
- Conduct coordinated SUW mission planning, contribute to and receive the common tactical picture, and initiate engagement of surface threats. Maintain and share situational awareness and tactical control in a coordinated SUW environment. When operating in company with other

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<sup>69</sup> Global Security Org., 2006.

SUW assets, such as fixed-wing/rotary wing attack aircraft and maritime patrol aircraft, the LCS must be capable of planning and coordinating the SUW mission.

- Engage surface threats independently, as part of a LCS group, and in coordination with other friendly forces. This includes threats in the line-of-sight and over-the-horizon. In addition to hard kill capabilities, the LCS will use agility and speed, signature management, and soft kill measures to disrupt the threat's detect-to-engage sequence and conduct offensive operations against surface threats.
- Deploy, control, and recover off-board systems and process data from off-board systems.
- Employ, reconfigure, and support MH-60 series helicopters and smaller rotary wing aircraft for SUW operations.
- Conduct SUW Battle Damage Assessment after engagements against surface threats.
- Conduct offensive ASW operations. The LCS must achieve a mission abort or sink a threat submarine if the submarine target of interest is transiting through a designated key choke point or operating (i.e., patrolling) in a designated search/surveillance area.
- Conduct defensive ASW operations. The LCS must defeat threat submarine attacks against units operating in company with carrier strike Groups, expeditionary strike groups, or LCS squadrons. The LCS must achieve a mission abort or sink a threat submarine that poses a threat to any friendly units.
- Conduct coordinated ASW, contribute to the Common Undersea Picture, maintain and share situational awareness and tactical control in a coordinated ASW environment.
- Maintain the surface picture while conducting ASW in a high-density shipping environment.
- Detect, classify, localize, track, and attack diesel submarines operating on batteries in a shallow water environment (including submarines resting on the sea floor.)
- Perform acoustic range prediction and ASW search planning.
- Conduct integrated undersea surveillance employing on-board and off-board systems.
- Achieve a mission kill of ASW threats through engagement with hard kill weapons from on-board and off-board systems.
- Employ signature management and soft kill systems to counter and disrupt the threat's detect-to-engage sequence in the littoral environment.

- Deploy, control, recover, and conduct day and night operations with towed and off-board systems, and process data from off-board systems.
- Employ, reconfigure, and support MH-60R in ASW operations.
- Conduct ASW Battle Damage Assessment after engagements against undersea threats.
- Support a Naval Special Warfare (NSW) Task Unit and surface/subsurface combatant craft and mobility platforms; or their JSOF equivalent including weapons and equipment storage, berthing, C4ISR connectivity, and space within the hull for mission planning and rehearsal.
- Launch, recover, and conduct organic maintenance on multiple embarked and organic craft.
- Support Marine Expeditionary Unit (Special Operations Capable) [MEU (SOC)] and JSOF hostage rescue operations and aircraft operations for helicopters such as the MH-60S.
- Support maritime special operations with the capability to refuel MK V special operations craft (SOC) and follow-on (special operations forces) medium range insertion craft (MRIC).
- Support SOF in noncombatant evacuation operations (NEO).
- Provide compressed air (diver quality) for the SEAL delivery vehicle (SDV).
- Embark a fly away recompression chamber (FARC).
- Support and conduct combat search and rescue (CSAR) operations.

## **E. LITTORAL COMBAT SHIP PROPOSED DESIGNS**

U.S. Navy planners are acquiring two different prototypes of the Littoral Combat Ship. A (1) Lockheed Martin team will tap its Aegis expertise to deploy COMBATSS-21, an acronym for component-based total ship system. A (2) General Dynamics team, meanwhile, is enlisting partners to help build the core mission systems infrastructure. Both the Lockheed Martin and General Dynamics teams say their systems will rely on open architecture and commercial-off-the-self (COTS) technologies. Team members say they will use the latest commercial software and enable simple, frequent hardware upgrades. Both teams are relying on software reuse to borrow components from a handful of other weapons and command systems. The similarities end there. The Lockheed

Martin vessel is a semi-planing monohull about the size of an Oliver Hazard Perry class frigate, while the General Dynamics version is a three hulled catamaran, roughly comparable in size to an Arleigh Burke-class destroyer.<sup>70</sup>

### **1. Lockheed Martin LCS Design**

The Lockheed Martin (LM) team design (Figure 15), a proven semi-planing steel monohull, provides outstanding agility and high-speed maneuverability with known seakeeping characteristics to support launch and recovery operations, mission execution, and optimum crew comfort. The Lockheed Martin-led team includes the naval architectural firm Gibbs & Cox, shipbuilders Marinette Marine and Bollinger Shipyards.<sup>71</sup>

Lockheed Martin's LCS is based on technologies introduced by Italian shipbuilder Fincantieri on the 1,000 t Destriero commercial vessel, which holds the transatlantic speed record, and the 3,000 t Jupiter Class. The ship has a steel hull with aluminum superstructure and will be powered by two Rolls-Royce MT30 36MW gas turbines and two Fairbanks Morse Colt-Pielstick 16PA6B STC diesel engines driving four large, acoustically optimized Rolls-Royce waterjets. Four Isotta Fraschini Model V1708 ship service diesel generator sets provide auxiliary power. The ship's maximum speed is 45 knots. The overall length is 115.5 meters. The maximum beam width is 13.1 meters and the draft is 3.7 meters.<sup>72</sup> Figures 16 and 17 show different sections of LM's LCS.

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<sup>70</sup> Ames, 2004.

<sup>71</sup> Lockheed Martin, 2006.

<sup>72</sup> Naval Technology Web Page 2006.



Figure 15. General Concept of LM LCS<sup>73</sup>



Figure 16. LM LCS Side Door, Launch, Recovery and Handling System, Flight Deck, and Stern Ramp<sup>74</sup>

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<sup>73</sup> Global Security Org., 2006.

<sup>74</sup> Global Security Org., 2006.



Figure 17. LM LCS Crew Areas, Aircraft Hangar, and Weapon Module Stations<sup>75</sup>

Lockheed Martin engineers tested a complete ship system by installing it aboard Sea Slice, an experimental, 104-foot, four-hulled U.S. Navy catamaran. Sea Slice participated in Fleet Battle Experiment Juliet, a joint service exercise in July 2002. The ship's role was to imitate the future LCS and demonstrate Navy requirements such as the ability to quickly add different modules for new missions and update the modules for a new battle task each time. Sailors used COMBATTs to run the ship's radar, identify friend or foe (IFF) system, NetFires missiles, and Millennium Gun. The Lockheed Martin engineers also tested earlier versions of COMBATTs aboard the Swift when the vessel deployed to the Persian Gulf in 2002. After that deployment, the Lockheed Martin engineers improved the system to handle 3D radar, the MK3 57 mm gun, and ICWS Plus, which includes a control suite to handle the LCS suite of off-board vehicles, such as helicopters, unmanned aerial vehicles, and remote mine hunters.<sup>76</sup>

While more than a football field in length, the Lockheed Martin LCS can operate in extremely shallow water—giving the ship access to thousands more ports and littoral waters worldwide than today's Navy combatants. It can turn 360 degrees in less than eight boat lengths at its rated sprint speed; it also can accelerate to full speed in less than

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<sup>75</sup> Global Security Org., 2006.

<sup>76</sup> Ames, 2004.

two minutes. The design combines high-speed maneuverability with a comfortable seakeeping motion that supports launch and recovery, combat operations, and optimal performance from the crew. The semi-planing monohull design provides transformational performance with a high degree of confidence. With all these capabilities Lockheed Martin's LCS will be equipped with TRS-3D surveillance and target acquisition radar system for better C4ISR operations.<sup>77</sup>

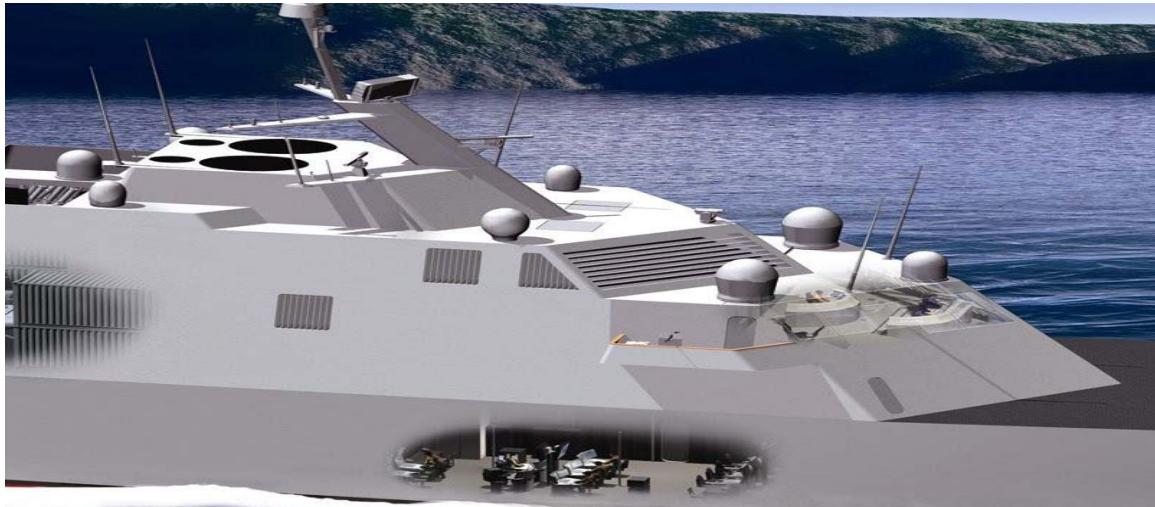


Figure 18. LM LCS Mission Systems, Fully Integrated Comms Suite<sup>78</sup>



Figure 19. LM LCS Modular Weapon Zone<sup>79</sup>

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<sup>77</sup> Lockheed Martin, 2004.

<sup>78</sup> Global Security Org., 2006.

<sup>79</sup> Global Security Org., 2006.

Specifications		
Category	Threshold Level	Objective Level
<b>Total Price per Ship</b>	Meet CAIV target in the REP	Exceed CAIV target in the REP
<b>Hull Service Life</b>	20 Years	30 Years
<b>Draft at Full load</b>	20 feet	10 feet
<b>Displacement</b>		
<b>Sprint Speed at Full Load Displacement in Sea State #</b>	40 Knots in Sea State 3	50 Knots in Sea State 3
<b>Range at Sprint Speed</b>	1,000 nautical miles	1,500 nautical miles
<b>Range at Economical Speed</b>	3,500 nautical miles (>18 knots) with payload	4,300 nautical miles (20 knots) with payload
<b>Aviation Support</b>	Embark and hangar: one MH-60R/S and VTUAVs, and a flight deck capable of operating, fueling, reconfiguring, and supporting MH-60R/S/UAVs/NTUAVs	Embark and hangar: one MH-60R/S and VTUAV5, and a flight deck capable of operating, fueling, reconfiguring, and supporting MH-60R/S/UAVs/NTUAVs
<b>Aircraft Launch/Recover</b>	Sea State 4 best heading	Sea State 5 best heading
<b>Watercraft Launch/Recover</b>	Sea State 3 best heading within 45 mins.	Sea State 4 best heading within 15 mins.
<b>Mission Package Boat type</b>	11 Meter RHIB	40 ft High Speed Boat
<b>Time for Mission Package Change-Out to full operational capability including system OPTEST</b>	4 days	1 days
<b>Provisions</b>	336 hours (14 days)	504 hours (21 days)
<b>Underway Replenishment Modes (UNREP)</b>	CONREP VERTREP and RAS	CONREP VERTREP and RAS
<b>Mission Module</b>	180 MT (105 MT mission package / 75 MT mission package fuel)	210 MT (130 MT mission package / 80 MT mission package fuel)
<b>Payload (note 3)</b>		
<b>Core Crew Size</b>	50 Core Crew Members	15 Core Crew Members
<b>Crew Accommodations (both core crew and mission package detachments)</b>	75 personnel	75 personnel
<b>Operational Availability (Ao)</b>	0.85	0.95

Table 11. Littoral Combat Ship Specifications<sup>80</sup>

<sup>80</sup> Global Security Org., 2006.

The laying of the keel celebrates an important milestone in the life of the USS FREEDOM (LCS 1) and marks a significant event for the construction of the U.S.'s first Littoral Combat Ship. The USS FREEDOM (LCS 1) will be delivered to the Navy in late 2006. Figure 20 shows the emblem of the first LCS – USS Freedom.



Figure 20. Emblem of USS Freedom (LCS 1)<sup>81</sup>

## 2. General Dynamics LCS Design

The General Dynamics (GD) approach (Figure 23) features an innovative trimaran hull that enables the ship to reach sustainable speeds of nearly 50 knots and a range as far as 10,000 nautical miles with a large interior volume and payload. The ship is designed to allow a crew of fewer than 40 sailors to fully operate, maintain, and defend it.

Key characteristics of the ship proposed by the General Dynamics team include:

- Capable of supporting several missions simultaneously. Open-architecture information systems enable over-the-horizon surveillance and reconnaissance; global networking; and coordinated air, surface, and undersea tactical picture.
- Incorporation of stealth technologies increases ship and crew survivability.

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<sup>81</sup> Lockheed Martin, 2006.

- Shallow draft allows operations near the shore. (Figure 21)
- Large payloads per ton of displacement.
- Huge interior volume delivers enhanced mission capabilities and endurance.
- Supports concurrent and simultaneous operation of two large (SH-60) helicopters. (Figure 22)

The General Dynamics LCS team will complete the design and construct a high-speed, 127-meter surface combatant ship for delivery to the Navy in October 2007. It will have a large usable payload volume and will provide the flexibility to carry out one mission while a separate mission module is in reserve. Its large flight deck sits higher above the water than any other U.S. Navy surface combatant and will support near-simultaneous operation of two SH-60 helicopters or multiple unmanned vehicles. And its open-architecture electronics suite significantly contributes to the ship's ability to facilitate a wide range of missions, while incorporating stealth technology to increase crew and ship survivability.<sup>82</sup>

Bath Iron Works is leading a team that includes Austal USA (Mobile, Alabama), which is responsible for building the team's aluminum and steel trimaran warship. General Dynamics Advanced Information Systems (Arlington, Virginia.), is leading the ship's open-architecture-based Core Mission System design and integration from its Pittsfield, Massachusetts, facility.<sup>83</sup>

Members of the Bath Iron Works / General Dynamics team include:

- BAE Systems Applied Technologies Inc., (Rockville, Maryland.), to build the ship's internal and external communications systems, as well as topside antenna modeling and mission module-interface coordination;
- CAE USA Inc., Marine Systems, (Leesburg, Virginia.), to be responsible for the ship automation and control system;
- Northrop Grumman Electronic Systems, (Baltimore, Maryland), to be responsible for Integrated Combat Management System (ICMS);

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<sup>82</sup> General Dynamics, 2006.

<sup>83</sup> PR Newswire Association, 2006.

- General Dynamics Armament and Technical Products, (Charlotte, North Carolina) to be responsible for all of the weapons and effectors;
- General Dynamics (Canada, Ottawa), to be responsible for the above-and below-water sensors.

The team approach builds on the General Dynamics Total Ship Computing Environment, a system that includes net-centric naval-combat management, real-time command and control, command support, and integrated shipboard sensors and weapons. It also includes Northrop Grumman's ICMS, which is the U.S. version of the TACTICOS combat management system, currently installed onboard more than 80 naval ships from 11 countries.<sup>84</sup>

SPECIFICATIONS	
<b>Length</b>	127.1 meters
<b>Beam</b>	30.4 meters
<b>Draft</b>	4.5 meters
<b>Sprint Speed</b>	45 knots
<b>Propulsion</b>	2 Gas Turbines, 2 Diesel Engines, 4 Steerable Waterjets, 1 Steerable Thruster
<b>Armament</b>	Surface to Air Missile Launcher, 57 mm Gun, Minor Caliber Guns, Decoys, and Countermeasures

Table 12. GD LCS Specifications<sup>85</sup>

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<sup>84</sup> Ames, 2004.

<sup>85</sup> General Dynamics, 2006.



Figure 21. GD LCS Trimaran Design<sup>86</sup>

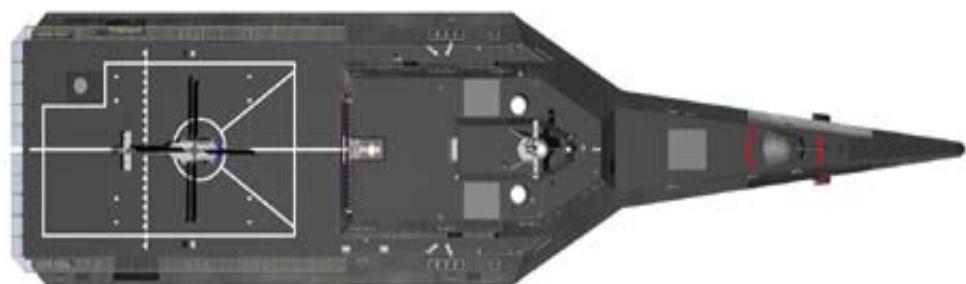


Figure 22. GD LCS Top View<sup>87</sup>

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<sup>86</sup> Lockheed Martin, 2006.

<sup>87</sup> Lockheed Martin, 2006.



Figure 23. GD LCS Front View<sup>88</sup>

#### **F. LITTORAL COMBAT SHIP CREW TRAINING**

One of the challenges you have in building a ship is that you have these ebbs and flows of activity for the crew. Because we have such a small crew, it's less of an issue for us. We'll have another increment of orders cut within the next couple of months. We have to get those sailors on board so that they can get to vendor training for the new systems on the ship and the Navy training for some of the systems. This is a very different process to train those people, so we are bringing them on board fairly early relative to other shipbuilding processes.

Cmdr. Donald Gabrielson  
Commanding Officer of the USS Freedom (LCS 1)

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<sup>88</sup> Lockheed Martin, 2006.

The U.S. Navy's Littoral Combat Ship (LCS) USS Freedom will be the first major vessel to become operational in the service's new family of advanced, networked ships designed for littoral operations. The LCS class will act as a platform for launch and recovery of manned and unmanned vehicles and its modular design will support interchangeable mission packages that will allow the ship to be reconfigured on an as-needed basis. It will be the first U.S. major combat ship to feature embedded training systems from its very inception.

To coordinate the development and implementation of training systems for all classes of old and new ships, the U.S. Navy has established the Total Ship Training (TST) program, a part of the Naval Sea Systems Command (NAVSEA) organization. The U.S. Navy has concluded that embedded training systems offer several advantages over other current surface-training systems such as separate add-on trainers appended to ship systems to simulate sensors and send simulated images to operators.

In the case of new ships like the LCS, the U.S. Navy has the opportunity to write all of its training requirements on a new slate. Providing the most effective on-demand training is particularly important for this class of ship, since it is optimally manned with a core seaframe crew of only 40. Training must also be provided for new combat and operations systems, as well as for different types of combat scenarios.

General Dynamics Advanced Information Systems (GDAIS) is the lead training contractor for the General Dynamics variant. In addition to initial training systems and courseware, the LCS seaframe contractors will be responsible for all updates and changes to the training curriculum to accommodate changes in U.S. Navy doctrine, operations, and equipment. Any electronic courseware deployed for the LCS will have to comply with the standards and structure of the navy integrated learning environment. All subsystem providers will have to provide all training materials to the LCS training contract lead company.<sup>89</sup>

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<sup>89</sup> Weirauch, 2005.

The U.S. Navy is developing the first group of sailors to serve on a vessel that is revolutionary in its technology as well as in how it will be manned and employed. To aptly prepare the crew members, the service is revamping some of its training curricula so these sailors can handle the multitude of tasks required in a totally systems- integrated environment. This is the first time the groundwork for a ship's manning as well as its training requirements is being based on job-task analyses conducted across the enlisted community.

Although the LCS seaframe is comparable in size to a frigate, crew size cannot be compared absolutely. While a frigate goes to sea with a crew of approximately 200 on board, plans for the LCS seaframe call for it to be manned by a core crew of 40 personnel: eight officers and 32 enlisted personnel. If a mission involves the use of helicopters, an aviation deck crew of 20 individuals is added to support helicopter operations. Because the capabilities of the LCS are modular, further additions to the crew will depend on the specific mission.

Recognizing that a traditional approach for assigning sailors to ships would not be adequate for LCS crews, the U.S. Navy analyzed job tasks, identified the required skills, and crafted what it calls Human Capital Objects (HCOs) that comprise information about work, workers, and workplaces. HCOw refers to the work and workplace requirements; HCOi refers to the individual with the skills to accomplish the tasks.

The LCS design revamps the typical ship. Capt. Rick Easton states:

Technologically, one of the other key aspects that's revolutionary in the ship is that we have a single computing environment that links all of the weapons systems into the same computer and plugs the mission module into that computing environment that also runs the ship's navigation, engineering and all the administrative functions. So this is really the first time that we've had a completely integrated computing environment on a ship. The TSCE watch stander is the one who's responsible for monitoring, maintaining, running and operating that computing environment. It's a very big job, and you can see how it would then draw skill sets that cross all of our systems and all the various ratings. When you have the optimum number of people-a critically manned crew-there's not time to do training based on a large apprentice base of sailors aboard the ship. So we're going to have to do that training ashore, and we're going to have to do that training in the future aided by computer-based as

well as simulation technology. We are moving today to purchase the shore-based operations trainer that's going to provide functionality for what we have in the past known as the Combat Information Center, which in this ship is the Mission Control Center.<sup>90</sup>

Computers and simulation also are likely to support training for the bridge operations because a number of systems management consoles will be located on the bridge, including navigation control, engineering plant management, and combat systems.<sup>91</sup>

The U.S. Navy plans to rotate multiple crews in three- to four-month cycles on the LCSs applying a technique that has increased the operational availability of legacy surface ships in previous experiments. Crew swapping on the Sea Fighter and Swift has shown that after about 90 to 120 days of constant operations, "the crews drag a little bit, and it's a nice time to do the swap," according to Vice Adm. Terrance Etnyre, Commander of Naval Surface Forces. Requirements for conducting proficiency training tend to be quarterly anyway, so the three- to four-month crew rotation would fit in well with training needs. But when the LCS actually gets under way, sailors probably will recommend improvements to the crewing concept. The LCS is expected to operate at a high tempo, and there will not be much time for crews to train at sea. Therefore, much of the training would be done at the ship's home port through simulators when the crew is not at sea.<sup>92</sup>

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<sup>90</sup> Lawlor, 2005.

<sup>91</sup> Lawlor, 2005.

<sup>92</sup> Inside Washington Publishers, 2006.

## **V. ASSETS FOR LITTORAL COMBAT USED BY OTHER COUNTRIES**

### **A. VISBY CLASS CORVETTE (SWEDEN)**

The Visby Class of stealth corvettes is being built for the Swedish Navy by the Swedish company Kockums (a subsidiary of ThyssenKrupp Marine Systems of Germany). Construction began in 1996 at Kockums' Kalrskrona yard. The Visby (K31) was launched in June 2000 and was delivered to the FMV (the Swedish Defense Materiel Administration) in June 2002 for fitting with weapons and combat systems. Entry into service is scheduled for early 2006. The second ship in this class, HMS Helsingborg (K32), was launched in June 2003 and the third, Harnosand (K33), in December 2004. The other hulls are: Nykoping (K34) and Karlstad (K35). The five Visby class vessels are to be delivered to the Swedish Navy by 2007. The Swedish Navy has an option on a sixth vessel (Uddevalla K36).

The primary missions of the first four Visby corvettes for the Swedish Navy are mine countermeasures (MCM) and anti-submarine warfare (ASW). The last vessel will be primarily performing attack and anti-surface warfare roles. A helicopter, such as the AgustaWestland A109M selected by Sweden, can land, take off, and refuel on the upper deck. Preparation has been made for the installation of a hangar on the ship.

Kockums has signed a partnership agreement with Northrop Grumman Ship Systems, under which Kockums will join Northrop Grumman's team for the U.S. Navy's Focused Mission Vessel Study for the design of the Littoral Combat Ship (LCS).<sup>93</sup>

The Visby-class corvette is the first naval vessel to feature fully developed stealth technology, and is constructed using carbon fiber. This makes these ships extremely difficult to detect, even when using the most modern and sophisticated radar and IR-sensor systems. The Visby corvette is designed to keep all signatures to a minimum. The hull features large, flat surfaces and sharp edges. Anything that is not absolutely essential on the outside of the hull or superstructure has been built into the main body of the ship,

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<sup>93</sup> Naval Technology Web Page, 2006.

or stays hidden under hatches. To ensure a minimal IR-signature, the gas turbine exhaust pipes and emissions are specially shielded at the stern, close to the surface of the water. The hull is entirely nonmagnetic, and onboard equipment is either demagnetized or constructed of nonmagnetic materials.<sup>94</sup>



Figure 24. The Visby-Class Corvette<sup>95</sup>

#### **B. SKJOLD CLASS MISSILE FAST PATROL BOAT (NORWAY)**

The Skjold class (The Norwegian Navy) of missile fast patrol boats is characterized by its speed, reduced signatures, small size with heavy weapon load, and its littoral combat capability. The Skjold (“Shield”) has an air-cushioned catamaran hull (surface effect) which, with waterjet propulsion, provides high speed and maneuverability.

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<sup>94</sup> Grahm, 2006.

<sup>95</sup> Jane's Information Group, 2006.

The first of class ship, KNM Skjold (P960), was commissioned in April 1999. The Norwegian government approved the construction of five more Skjold class vessels in June 2002. Contract negotiations were concluded in July 2003. The series of ships will be built at the Umoe Mandal shipyard and are planned for delivery from 2006-09. The other five hulls will be: Storm (P961), Skudd (P962), Steil (P963), Glimt (P964), and Gnist (P965).

In September 2002, the ship completed a 13-month deployment in the U.S.A., which allowed the U.S. Navy to study the Skjold class concept. The ship participated in a series of naval exercises and a number of tests with U.S. Navy research establishments NAVSEA and the Office of Naval Research. This was the result of a bilateral agreement in which the U.S. Navy reviewed the Skjold capabilities and performance as part of their transformational activities including Littoral Combat Ship (LCS) development.<sup>96</sup>



Figure 25. Skjold Class Missile Fast Patrol Boat<sup>97</sup>

#### **C. FEARLESS CLASS PATROL VESSEL (SINGAPORE)**

Singapore Technologies Marine Ltd (ST Marine), part of Singapore Technologies Engineering, built twelve Fearless class patrol vessels for the Republic of Singapore

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<sup>96</sup> Naval Technology Web Page, 2006.

<sup>97</sup> Jane's Information Group, 2006.

Navy (RSN). The RSN awarded the contract to ST Marine in February 1993 and the first of the Fearless class patrol craft was commissioned in the first quarter of 1996. The final vessel of the class was commissioned in May 1999.

The first six vessels of the class, Fearless (94), Brave (95), Courageous (96), Gallant (97), Resilience (98), and Unity (99), are armed for anti-submarine warfare missions. The remaining six vessels, Resilience (82), Unity (83), Sovereignty (84), Justice (85), Freedom (86) and Independence (87), are general patrol vessels.

The 55m patrol vessel uses a steel monohull with a round-bilge semi-displacement hull, and it incorporates very fine V-shaped frames in the forward sections. The superstructure is constructed in marine-grade light alloy. The design of the vessel allows the layout to be reconfigured to accept a range of sensors and weapons systems to meet the evolving operational requirements of the armed forces of the customer countries.<sup>98</sup>



Figure 26. Fearless Class Patrol Vessel<sup>99</sup>

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<sup>98</sup> Naval Technology Web Page, 2006.

<sup>99</sup> Jane's Information Group, 2006.

**D. ROUSSEN CLASS (62 METRE SUPER VITA) FAST ATTACK MISSILE CRAFT (GREECE)**

Elefsis Industrial Enterprises SA has been awarded the contract for the supply of three Super Vita 62 m fast attack missile craft for the Hellenic (Greece) Navy. The ships, called the “Roussen Class,” are being constructed at the Elefsis yard near Athens. Vosper Thornycroft provides design, construction support, ship’s equipment and logistics support services to Elefsis.

The initial requirement is for three fast attack craft, and part of the agreement includes provision of two ex-Royal Navy Hunt Class mine countermeasure vessels.

The fast attack craft has a displacement of 580t fully loaded. The first ship, HS Roussen (P67), was launched in November 2002 and was commissioned in December 2005. The second, HS Daniolis (P68), was launched in July 2003 and will be delivered in 2006. The third, HS Kristallidis (P69), was launched in April 2004 and is due for delivery in November 2006.

In September 2003, a contract was awarded for a further two ships (HS Grigoropoulos and HS Ritsos), to be built by Elefsis and delivered in 2006 and 2007.

The vessel’s sensor suite includes the Thales MW08 3D G-band surveillance radar, Thales Nederland Mirador electro-optical target tracker, an integrated Thales Nederland Scout Mark II low probability of intercept radar, and Northrop Grumman (formerly Litton) Marine Bridgemaster-E navigation radar.<sup>100</sup>

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<sup>100</sup> Naval Technology Web Page, 2006.



Figure 27. Roussen Class Fast Attack Missile Craft<sup>101</sup>

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<sup>101</sup> Jane's Information Group, 2006.

## E. COMPARISON BETWEEN LITTORAL COMBAT ASSETS

Table 13 shows the comparison between littoral combat assets in specifications and operational capabilities.

Specs.	Littoral Combat Assets					
	LCS LM	LCS GD	Visby	Skjold	Fearless	Roussen
<b>Length (m)</b>	115.5	127.1	73	46.8	55	62
<b>Beam (m)</b>	13.1	30.4	10.4	13.5	8.6	9.5
<b>Draft (m)</b>	3.7	4.5	2.4	2.3	2.7	2.6
<b>Speed (kts)</b>	45	45	35	57	20	35
<b>Full Load Displacement (Metric ton)</b>	3000	3000	620	260	500	580
<b>Complement</b>	65 <sup>102</sup>	65	43	15	32	45
<b>Capabilities</b>						
<b>ASW</b>	Yes	Yes	Yes	No	Yes	No
<b>ASuW</b>	Yes <sup>103</sup>	Yes	Yes	Yes	Yes	Yes
<b>AAW</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>MW</b>	Yes	Yes	Yes	No	No	No
<b>Aviation (inc. UAVs)</b>	Yes	Yes	Yes	No	No	No

Table 13. Comparison between Littoral Combat Assets in Specifications and Operational Capabilities

<sup>102</sup> The core crew on the LCS will be about 40 sailors with a detachment for mission modules numbering about 15 and an air crew detachment of about 10.

<sup>103</sup> The LCS will conduct ASuW operations against small surface crafts. The LCS will not carry ASCMs.

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## VI. CONCLUSIONS AND RECOMMENDATIONS

The one who rules the seas, rules the world.

Barbaros Hayrettin Pasha  
Admiral-in-Chief of the Ottoman Navy (1543–1546)

### A. CONCLUSIONS

The littoral environment and the enemy that may be encountered therein impose new demands on any naval forces. Naval forces that operate within the littoral environment are becoming increasingly vulnerable for the following reasons:

- geographical constraints
- limited battlespace
- reduced reaction time to incoming threats
- the lethality of enemy weapons
- ambiguous threat bearings
- clutter
- congestion
- uncertainty
- restrictive rules of engagement
- unrealistic and unattainable states of readiness
- the eventual degradation of weapon and sensor performance

Though the U.S. Navy conducted a formal requirements process and an analysis of other potential solutions, it did so after concluding that the LCS concept was the best option to address the challenges of operating U.S. forces in the littorals. Normally, a major acquisition program should include an examination of basic requirements and an analysis of potential solutions before a new system is decided upon. Based on the U.S. Department of Defense (DOD) reviews of the U.S. Navy's analysis and the revised acquisition guidance requirements, the U.S. Navy eventually examined a number of alternative solutions to address littoral capability problems, such as the extent to which existing fleet assets or joint capabilities could be used. The U.S. Navy still concluded that the LCS concept was the best option. However, the U.S. Navy's analysis of one area of

littoral operations—the surface threats facing U.S. forces in littoral waters—did not include consideration of the potential impact of all threats the LCS is likely to face. For example, while the requirements for the LCS are focused on combating small boats, the LCS could face larger threats in littoral waters, including missile-armed warships. Though the LCS is to rely on support from other nearby U.S. forces, the U.S. Navy also intends for the LCS to operate independently of those forces. The U.S. Navy has not analyzed how operating independently could pose additional risks to LCS.<sup>104</sup>

The survivability of the LCS in dangerous littoral waters is open to question. Speed, stealth, and battlespace awareness may not be sufficient to avoid being targeted and attacked by modern sensors and weapons, particularly in waters close to an enemy's shore. Also the LCS's modest self-defense weapons may not be adequate to counter incoming missiles and torpedoes.<sup>105</sup>

The requirements the U.S. Navy decided upon for the LCS's surface warfare capabilities were focused on small boats as the adversary, and this did not include an analysis of the impact of larger surface threats in the littorals. The U.S. Navy focused their analysis of the surface threat on swarms of small boats that are capable of operating at high speeds and employing shoulder-mounted or crew-served weapons, such as light machine guns. From or near shorelines, these boats can conduct short-range attacks that are simultaneous and have the element of surprise. The U.S. Navy measured its current and programmed capabilities against defeating swarms of small boats in high numbers. For example, to determine the capability problems and measures of effectiveness for escorting ships through choke points, the U.S. Navy measured its force structure against defeating large numbers of small boats. However, larger threats, such as missile-armed patrol boats and frigates, are also identified in the U.S. Navy's LCS concept of operations and threat studies as threats that the LCS may face in the littorals. Such vessels may be armed with medium caliber guns, torpedoes, and anti-ship missiles. These threats could present additional risks to LCS operations.

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<sup>104</sup> United States General Accounting Office 2001.

<sup>105</sup> O'Rourke and Library of Congress. Congressional Research Service, 2005.

U.S. Navy officials stated that if a larger surface threat were encountered, an LCS would be able to call upon the assistance of other U.S. forces in the area, such as tactical aviation or larger surface warships. In a major combat operation, it is true that LCS squadrons would be able to draw upon the assistance of those nearby navy or joint forces in the face of a larger surface threat in the area. However, according to the LCS concept of operations, in addition to operating with other U.S. forces on a regular basis, the LCS is intended to operate independently of those forces, depending on the types and circumstances of the missions. When operating independently, such as during routine deployments to littoral waters, the LCS may not be able to call upon assistance from larger U.S. forces. This may impede LCS operations and may force the LCS to withdraw from an operating area. This situation would be contrary to the U.S. Navy's goals. Since the U.S. Navy did not analyze the impact of larger surface threats on LCS operations, the extent of the risk and the impact on littoral operations is not known.<sup>106</sup>

Those who are skeptical of the LCS program could argue that, although U.S. Navy computer simulations and war games may show that a ship like the LCS would increase the U.S. Navy's war fighting effectiveness in the littoral environment, the U.S. Navy has not shown that this increase is greater than the increase that might be achieved by investing a similar amount of funding in other approaches for performing littoral warfare missions. Without thoroughly examining potential alternative approaches, the U.S. Navy identified a need for additional littoral war fighting capability and seemingly leaped to the conclusion that the LCS would be the best way to provide it. Helicopters, frigates, and submarines have performed littoral warfare missions for years, and the U.S. Navy has not shown through rigorous analysis why these platforms—or unmanned vehicles deployed from manned aircraft, submarines, or larger surface ships operating further from shore—would be inferior to the LCS for performing such missions.

On the other hand, supporters of the LCS could argue that the LCS program represents the best possible approach for performing the LCS's stated missions because the LCS program would exploit the new concept of modular payload packages to achieve

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<sup>106</sup> United States General Accounting Office, 2001.

significant mission flexibility. The LCS also has an improved ability to accept upgrades and new missions over its life-cycle and would take full advantage of unmanned vehicles.<sup>107</sup>

Tables 14 and 15 show the comparison between U.S. LCS and the Turkish Navy's surface combatants in specifications and operational capabilities.

Specs.	Littoral Combat Assets					
	LCS LM	LCS GD	Yavuz/ Barbaros	Gabya	Burak (Type A 69)	Tepe
<b>Length (m)</b>	115.5	127.1	118	138.1	80.5	134
<b>Beam (m)</b>	13.1	30.4	14.8	13.7	10.3	14.3
<b>Draft (m)</b>	3.7	4.5	6.4	7.5	5.5	7.8
<b>Speed (kts)</b>	45	45	32	29	23	27
<b>Full Load Displacement (Metric ton)</b>	3000	3000	3380	3638	1250	4260
<b>Complement</b>	65 <sup>108</sup>	65	187	206	104	288
<b>Capabilities</b>						
<b>ASW</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>ASuW</b>	Yes <sup>109</sup>	Yes	Yes	Yes	Yes	Yes
<b>AAW</b>	Yes	Yes	Yes	Yes	Yes	No
<b>MW</b>	Yes	Yes	No	No	No	No
<b>Aviation (inc UAVs)</b>	Yes	Yes	Yes	Yes	No	Yes

Table 14. Comparison between U.S. LCS and the Turkish Navy Frigates in Specifications and Operational Capabilities

<sup>107</sup> O'Rourke and Library of Congress. Congressional Research Service, 2005.

<sup>108</sup> The core crew on the LCS will be about 40 sailors with a detachment for mission modules numbering about 15 and an air crew detachment of about 10.

<sup>109</sup> The LCS will conduct ASuW operations against small surface crafts. The LCS will not carry ASCMs.

Specs.	Littoral Combat Assets					
	LCS LM	LCS GD	Kilic/ Kilic II	Dogan/ Ruzgar	Yildiz	Kartal
<b>Length (m)</b>	115.5	127.1	64.2	58.1	57.3	42.5
<b>Beam (m)</b>	13.1	30.4	8.3	7.6	7.6	7
<b>Draft (m)</b>	3.7	4.5	2.6	2.7	2.7	2.4
<b>Speed (kts)</b>	45	45	38	38	38	38
<b>Full Load Displacement (Metric ton)</b>	3000	3000	550	436	433	190
<b>Complement</b>	65	65	46	40	45	39
<b>Capabilities</b>						
<b>ASW</b>	Yes	Yes	No	No	No	No
<b>ASuW</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>AAW</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>MW</b>	Yes	Yes	No	No	No	No
<b>Aviation (inc UAVs)</b>	Yes	Yes	No	No	No	No

Table 15. Comparison between U.S. LCS and the Turkish Navy Guided Missile-Fast Attack Crafts in Specifications and Operational Capabilities

## B. RECOMMENDATIONS

The following recommendations represent the personal opinions of the author and are not to be taken as the proven method by which proficiency and synergy of forces is to be obtained within the littoral environment.

The author is making the following recommendations for the Turkish Navy:

- To wait for the operational test and evaluation results of the LCS and see whether it meets the performance requirements mentioned in Chapter IV. The U.S. Navy will revise its acquisition strategy to ensure that it has sufficiently experimented with both of the Flight 0 ship designs, captured lessons learned from Flight 0 operations with more than one of the mission

packages, and mitigated operational and technology risks before they select a design for the Flight 1 ship or award a contract for the construction of the Flight 1 ship.

- To analyze the cost-effectiveness of the LCS as a focused-mission ship employing modular mission payload packages rather than as ship with a built-in multi-mission combat system that the Turkish Navy is currently using. LCS mission modules would not be changed in open waters; they would be changed in a friendly port. If the friendly port is near the LCSs' operating area, then LCSs are not needed in that area. If the friendly port is not near the operating area, the LCSs will not be able to change mission modules in a timely manner. The storage of the mission modules that are not loaded on the LCS could be a problem in the theater of operation.
- To conduct an analysis of the ability of the LCS program to achieve and exploit the concept of network-centric warfare that will be a key component of naval transformation. The LCS program will be helpful for the evaluation of future littoral combat ship programs such as the MilGem (National Vessel) program.
- To consider other littoral combat assets mentioned in Chapter V. A Turkish LCS will fight in the Aegean Sea, a relatively shallow body of water with many surface (such as islands and shoals) and sub-surface obstacles and tactically complex water that provides shallow-draft warships excellent locations for scouting, attack, and concealment; the Mediterranean Sea and the Black Sea with dense maritime traffic that can challenge the building and maintenance of an operationally useful maritime picture and blur the lines between neutral and foe. From the comparison between littoral combat assets table (Table 13) stealth, fast, and small surface combatant such as Visby class corvette can conduct ASuW missions against ASCM-armed warships, MW missions, and ASW missions against small diesel submarines in the Turkish Navy's areas of responsibility.

The author suggests that the key components of naval force transformation for littoral operations rest upon new concepts such as the U.S. Navy's Littoral Combat Ship. For the Turkish Navy, it is important to apply its littoral combat experience to the LCS use in joint operations with other branches of the Turkish Armed Forces. The Turkish Navy's warships, aircraft, and submarines are designed for operations in the littoral environment. Also, Turkish Navy personnel are trained for the intricacies of operating in the littoral environment. These facts will help to adapt the LCS concept as force transformation continues.

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